POWER PLANT ENGINEERING

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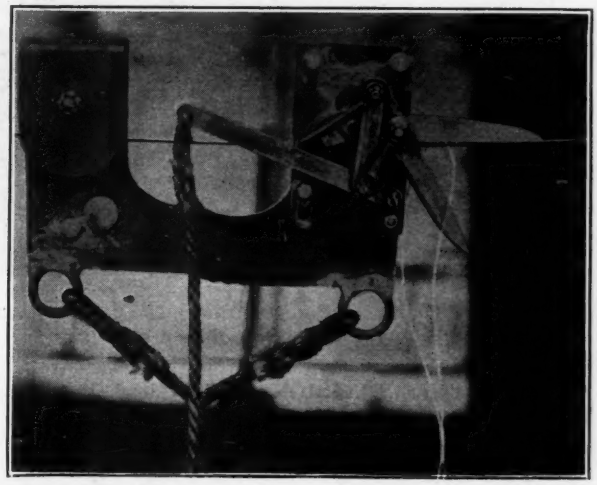


What's In a Name?

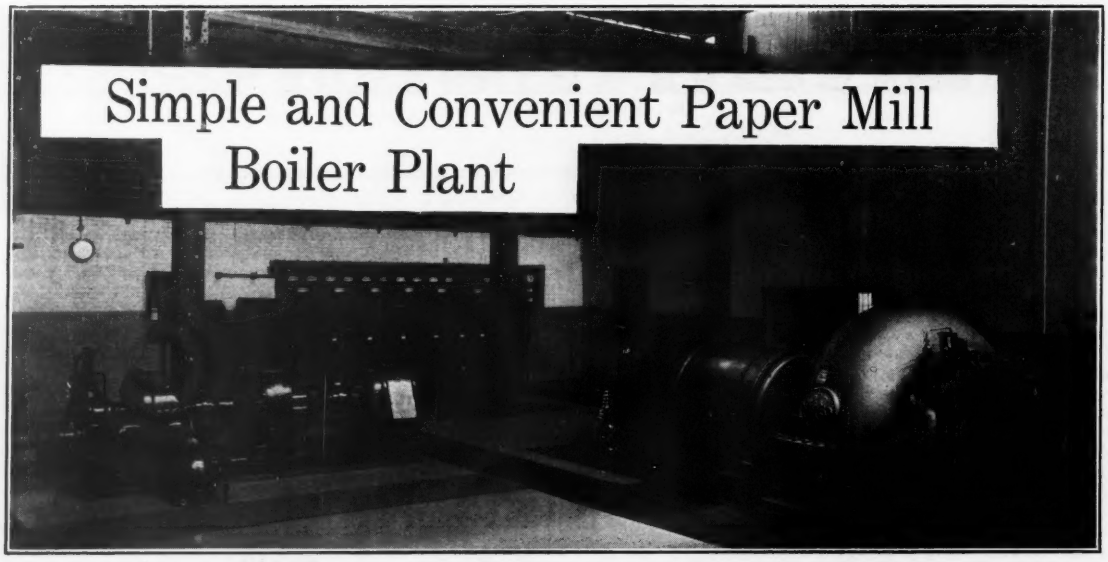
"WHAT'S IN A NAME?" quoth Mr. Shakespeare some three centuries back while gazing fondly at a cabbage, "that which we call a rose, by any other name would smell as sweet."

Maybe so,—maybe so. Bill was a smart fellow who usually knew his onions—we beg pardon, we meant his roses, and we don't like to disagree with him. Yet, in this instance, we have our doubts. The statement may be perfectly true about a rose or a cabbage, but the question is, is it general enough to apply to all things?

Take "High Voltage Lizzie" shown above, for instance, who glides along on 60,000 v. with her jaws wide open, charged with fight to the gills. A strange bird, you say—a cross between a double humped camel and a pelican. Look at her closely; note her proud carriage, her powerful digestive organs and her snappy features. Yes sir, she eats corona and kite strings and never whimpers.

What's in a name? Well, who else could have invented a bird like Lizzie but a lineman named Hightower. Albert Hightower, a lineman of Fresno, Calif. By the gods! there is a man whom fortune favored by giving him a name so suited to his profession that when kite strings and rags became tangled up in his transmission line, he sat down and invented Lizzie to bite them off. And how ingenious! A trolley truck riding on the wires and a strong pair of shears operated by a rope. Linemen on the San Joaquin Light & Power Co. who have been using her for a year have become much attached to her.

Simple, you say? Simple, indeed, for a lineman named Hightower. Don't tell us there's nothing in a name.



Simple and Convenient Paper Mill Boiler Plant

THREE 1057-HP. BOILERS, SUPPLIED WITH PULVERIZED COAL FROM SEPARATE COAL PREPARATION HOUSE, SUPPLY STEAM FOR THE MEAD PULP & PAPER CO., CHILLICOTHE, OHIO. BY J. F. RHOADES*

CHILLICOTHE DIVISION of The Mead Pulp & Paper Co. at Chillicothe, Ohio, large producer of magazine paper, has been one of the few mills electrically equipped since 1920, having all its paper machines motor-driven except one. Two of the first sectional motor drives were installed in 1920. The power plant was equipped with three 3000-kw. extraction type turbines to supply the necessary steam at 15 lb. pressure for drying paper and heating. A 750-kw. condensing unit was used for Sunday load and miscellaneous services and the original plans 10 yr. ago were to expand to possibly three of this size. The present total of 9750 kw. indicates the actual expansion.

*Chief engineer, The Mead Pulp & Paper Co.

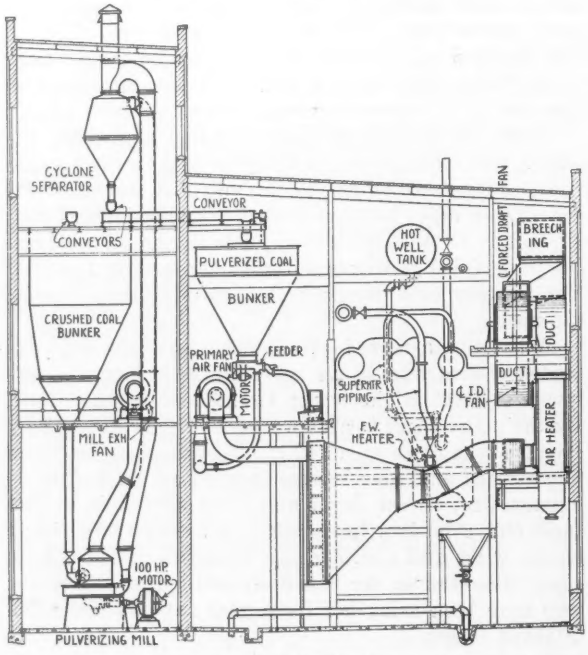


FIG. 1. CROSS-SECTION THROUGH NEW BOILER PLANT, SHOWING PREPARATION PLANT, FEEDERS AND DRAFT EQUIPMENT

Now the company has in operation a complete up-to-date pulverized fuel steam plant. The old plant was kept operating while testing out and cutting in the new plant. The coal preparation building is separate but adjacent to the boiler plant and is equipped with pulverizers, coal handling equipment with magnetic separator, exhaust fans, cyclone separators and raw coal bins, no coal drying apparatus being employed.

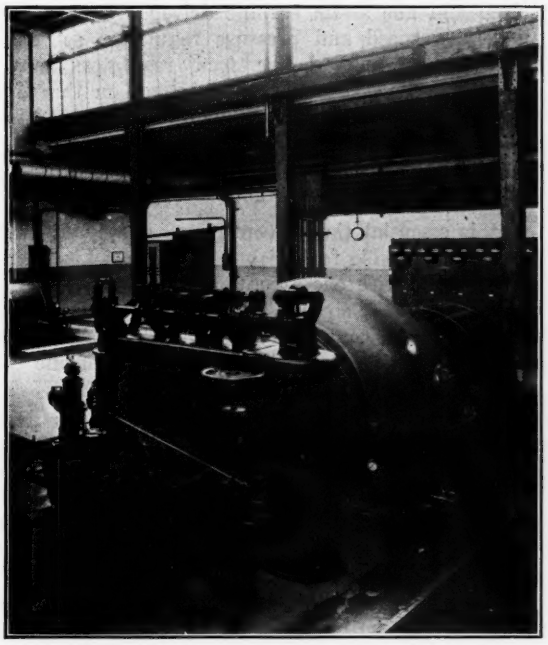
Boilers are 1057-b.hp., v-type units with superheaters and water screens and fin tube furnace walls. The front walls are air-cooled. Three boilers are now in operation with expansion space provided for the fourth. A master control switchboard enables the operator to control all boilers individually or together.

Each boiler is provided with a forced draft fan, induced draft fan, coal feed blower and insulated pulverized coal bin. Air preheaters recover the heat from the flue gas, which ordinarily leaves the boiler at 450 deg. and goes up the stack after the preheater at 270 deg.

OPERATION AND CONTROL

Normal operation of the paper mill requires the three 1057-hp. boilers to run at 200 to 220 per cent of rating. If one boiler is taken off the line, the remaining two run at 300 to 350 per cent of rating, maintaining without difficulty 14½ to 15 per cent CO_2 at an efficiency of 80 to 84 per cent averaged over a month, with low rating of one boiler on Sundays included in the average.

Coal used is West Virginia nut and slack of about 13,500 to 14,500 B.t.u. and with moisture content usually below three per cent. It is received direct from the mines in gondola cars and unloaded direct into a track hopper feeding through a coal crusher over a magnetic separator to remove any iron. It is then elevated to the raw coal bunkers. Six-roll pulverizers



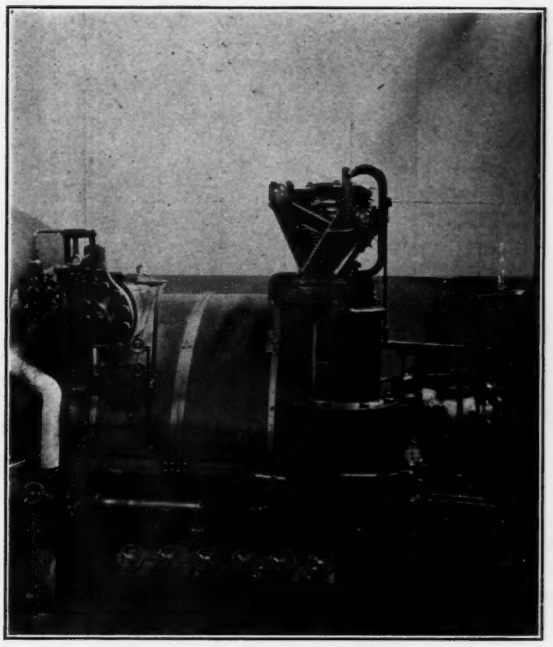


FIG. 2. VIEW IN TURBINE ROOM SHOWING ONE OF THE EXTRACTION TURBINES. FIG. 3. A CLOSEUP VIEW OF THE CONTROL END OF ONE OF THE TURBINES

located under the bunkers pulverize the coal to a fineness of 65 per cent through a 200-mesh screen. Coal is drawn from the pulverizers by exhauster fans and passes through cyclone separators, where the fine coal is deposited in screw conveyors, which convey it to the pulverized coal bunkers over each boiler. Bunkers are insulated to prevent coking; as the coal is heated to about 110 deg. in pulverizing, it will form coke on inside of bunkers if allowed to cool and condense.

Coal Pulverizers and Auxiliaries

This system is all closed and vented through a washer to eliminate the accumulation of coal dust. Pulverizers are supplied with makeup heated air at approximately 100 deg. drawn from the top of the boiler plant; the pulverizer room is supplied with heat in the same manner. In this way, the excess of waste heat accumulating at the top of boilers is re-circulated to the first floor of the pulverizer building, which has no source of heat in winter. This heat also assists in the pulverizers to carry off any excess moisture in the coal.

Pulverized coal bins over each boiler are provided with five motor-driven screw feeders, which feed the coal, mixed with preheated air, to the boilers through fan-tail burners. The balance of preheated air for combustion is supplied through ports in the front wall of

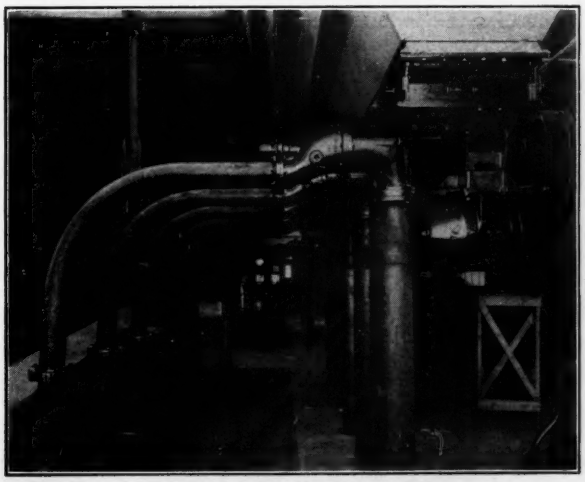


FIG. 4. FIVE SCREW FEEDERS SUPPLY PULVERIZED COAL TO FAN-TAIL BURNERS OF EACH BOILER

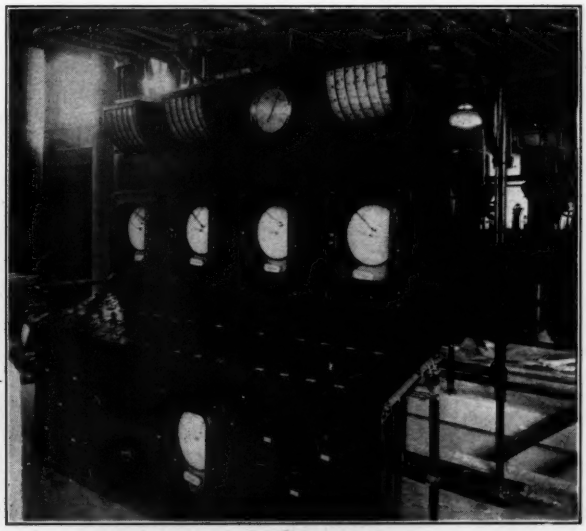


FIG. 5. BOILER CONTROL BOARD CARRIES ALL METERS AND SWITCHING EQUIPMENT FOR AUXILIARIES

FIG. 6. FORCED AND INDUCED DRAFT FANS ARE DRIVEN BY MULTIPLE-BELT DRIVE

the furnace. This air also assists in keeping the front wall cool; a portion of this air is supplied around the burners.

Ash accumulation in the bottoms of the furnaces is removed by a water sluice to a sump, where it is pumped to a settling tank and the water allowed to drain. The ash is then loaded into dump cars with a crane every two or three weeks. The dust accumulation in the back pass hopper can also be dropped directly to the water sluice, by opening a gate.

For starting up in case of a total shut-down of the power plant, two oil burners are installed on each furnace.

Feedwater Supply

Makeup water for boiler feed, which has a hardness of approximately 22 gr., is softened by a hot process softener with lime-soda ash treatment at 205 deg. This makeup and the condensate returns pass through a deaerator heater, which assists in removing the entrained oxygen from the water and supplies the boilers with uniform hot water at 203 deg. to 210 deg. As exhaust steam for heating water is not quite sufficient, extraction steam from the turbines is used to maintain this temperature.

Two boiler feed pumps are installed, one motor driven and one steam turbine driven. They are supplied with speed and pressure regulation so that an even flow through boiler feed regulators may be obtained. Pressure and altitude gages on the control board on the operating floor enable the operator to see that boiler feed pumps are operating properly.

Driving Motors Are All Interlocked

It is essential that a continuous supply of electric power be available for the boiler auxiliaries, which are motor-driven with one exception. To provide this supply, double power circuits from the power source run to the boiler house, connected with suitable circuit breakers and disconnecting switches so that failure of one power circuit will not shut down the auxiliaries.

In the coal handling system, the various driving motors are electrically interlocked so that they can be started only in the proper sequence. Furthermore, if one motor of a sequence should fail, all motors of the sequence will stop automatically. A similar arrangement is used with the motors of the pulverizing equipment. Also, in the case of furnace auxiliaries, fan motors are interlocked with coal feeder motors so that the fans must be operating before coal is delivered to the furnaces. This arrangement is to prevent backfiring of the burner and smoking in the furnace.

Instruments and Records

Boilers are equipped with individual steam flow meters to indicate and record steam flow, gas temperature, steam temperature and air flow. A totalizing steam flow meter records pressure of steam to plant. A boiler feedwater meter records pounds of water and temperature. A makeup water meter records pounds of water and temperature; also, final temperature of gas lost up stack from all boilers is recorded so that this loss can be computed. Indicating CO_2 meters are installed and a setting of air and steam flow is made on steam flow meters; thus the operator is able to keep an accurate check on this important item. The operator has all these instruments visible at the control board and by means of one-hand wheel can control air flow and coal feed to all boilers to such a point that the total steam demand is immediately taken care of.

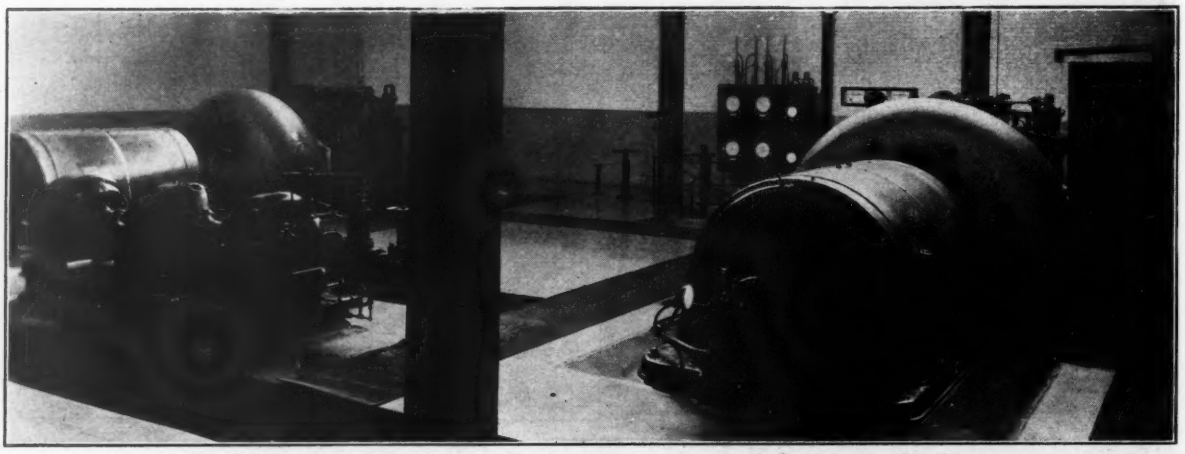


FIG. 7. THE TURBINE ROOM IS EXCEPTIONALLY CLEAN AND NEAT IN APPEARANCE

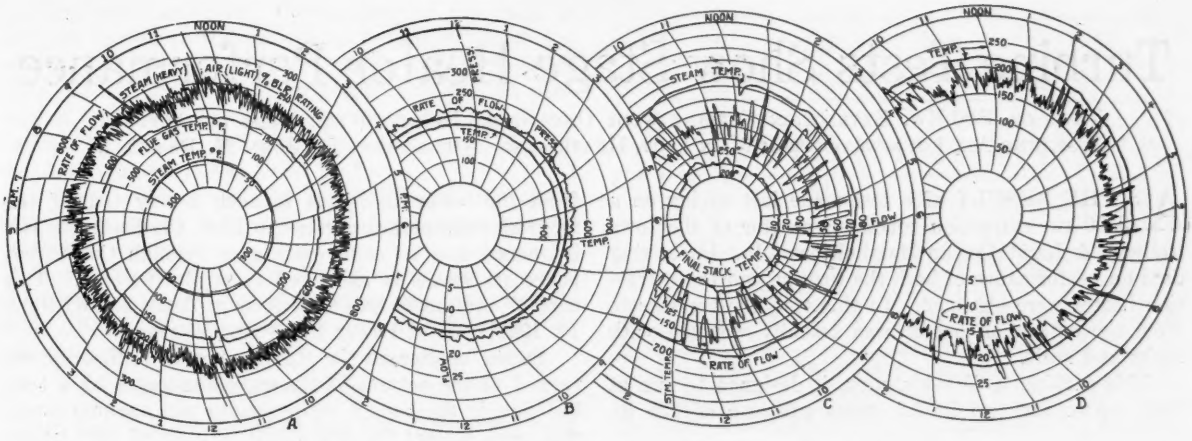


FIG. 8. TYPICAL CHARTS FROM BOILER INSTRUMENTS

A—Boiler No. 2 steam flow, air flow and steam and flue gas temperatures. B—Station steam pressure total steam flow, temperature. C—Makeup water, flow in pounds, water temperature, final stack temperature. D—Total feedwater flow in pounds and water temperature.

All records are averaged at the end of each month, including Sundays, using car weights for coal and meter readings. This method is also followed for the turbines in the power plant. With the instruments available, a check is maintained during operation on individual efficiency of equipment, thus keeping down losses and lowering the final plant cost. One operator is on duty at the control board and one engineer supervises feed water control, blow-downs, soot blowers and other miscellaneous items. Two men operate the coal preparation plant and there is one night foreman and superintendent.

About half of the steam produced is used for generating power; the balance is used for process work.

Figure 6 shows two of the 3000-kw. extraction turbines recently installed in the power house. These are 13-stage turbines with 3-lever extraction devices for 200 lb. pressure at the throttle and 15 lb. extraction pressure. They exhaust to double compartment condensers, in which one side can be cleaned while the other is operating. The generators are cooled by closed systems with automatic temperature signal devices. As now arranged, the power station allows space for two units besides those shown. This power plant was designed and built by the engineers of the company.

Design and construction of the steam plant were carried out by The Management Engineering and Development Co. of Dayton, Ohio, under the supervision of H. P. Carruth, general manager of The Mead Pulp & Paper Co., and John F. Rhoades, chief engineer.

PRINCIPAL BOILER HOUSE EQUIPMENT AT THE MEAD PULP & PAPER CO.

Coal Preparation Plant	
Coal handling equipment	Webster Mfg. Co.
Coal bunkers and bins	Littleford Bros.
Pulverizing mills, exhausters, cyclones and auxiliaries	Combustion Engineering Corp.
Driving motors	General Electric Co.
Boilers, Furnaces and Combustion Equipment	
3 Stirling boilers, heating surface—10,570-sq. ft. each, 205-lb. gage pressure, with B. & W. superheaters for 50-100 deg. superheat	Babcock & Wilcox Co.
3 furnaces, fin tube side and rear walls, Lopulco water screen	Combustion Engineering Corp.
Furnace arches and air-cooled front walls	M. H. Detrick Co.
3 Air preheaters	Combustion Engineering Corp.
15 Screw feeders and fan-tail burners (5 each boiler)	Combustion Engineering Corp.
9 Fans, 3 primary air, 3 forced draft, 3 induced draft	B. F. Sturtevant Co.
Concrete chimney	Heine Chimney Co.
Breeching	Connery & Co., Inc.
Water Treating and Pumping Equipment	
Hot process water softener	Cochrane Corp.
Deaerating heater	Cochrane Corp.
2 centrifugal boiler feed pumps, 1 turbine driven, 1 motor driven—capacity, 500 g.p.m. each, 575-ft. head	De Laval Steam Turbine Co.
Other Mechanical Equipment	
Soot blowers	Diamond Power Specialty Corp.
Feedwater regulators (Copes)	Northern Equipment Co.
Texrope drives for fans	Allis-Chalmers Mfg. Co.
Motors, switchboards and control equipment	General Electric Co.
Piping and valves	Crane Co.
Pipe insulation	Johns-Manville Corp.
Twin blowoff valves	Everlasting Valve Co.
Combustion control equipment	Hagan Corp.
Ranarex CO_2 recorders	Permutit Co.
Steam flow meters, water meters, draft gages, etc.	Bailey Meter Co.
Water columns	Babcock & Wilcox Co.
Safety valves	Babcock & Wilcox Co.
Atmospheric relief valves	Foster Wheeler Corp.
Auxiliary oil burning equipment	Schutte & Koerting Co.
Turbine-Generators and Auxiliaries	
2 turbine generators, each 3000 kw., extraction type	General Electric Co.
2 condensers	Foster Wheeler Corp.
Steam meters	Bailey Meter Co.
Generator air cooler	General Electric Co.
Dual exciter	General Electric Co.

While the oil industry employs oil temperatures considerably higher than the steam temperatures usually found in the power industry, the metal temperatures of the heat absorbing tubes are not radically different because of the greatly higher rate of heat absorption of oil over mixed water and steam as in a boiler. The nitrogen fixation industry has abandoned attempts to use metals at high temperatures because of excessive corrosion and is now limiting metal temperatures to 572 deg. F.

Metallurgical research has produced metal suitable for use at 900 deg. F. steam temperature, but to make the use of higher temperatures more general, less expensive alloys are needed. Careful consideration should be given to the design of heat transfer apparatus with a view toward lowering the metal temperature to that of the steam temperature.

Tampa Union Terminal Co., Tampa, Fla., has perfected plans for its proposed new cold storage and refrigerating plant on 9½ acres of water front property and will proceed with superstructure at once.

Turbine Tests Show Stage Heater Performance

TESTS OF 3500-KW. EXTRACTION TURBINE WITH ONE STAGE HEATER WERE MADE BY ACTUALLY WEIGHING ALL CONDENSATE FROM MAIN UNIT, HEATER AND ACCESSORIES. BY JOHN M. DRABELLE*

AS THE RESULT of a test made last spring on a 3500-kw. extraction turbine-generator of the Iowa Railway & Light Co. at Marshalltown, Ia., interesting data on performance of both the turbine and the extraction heater were obtained. In this test, the condensate from the extraction heater was actually weighed with tanks and scale.

This turbine, a 3500-kw. unit, is designed to run at 3600 r.p.m. with an initial steam pressure of 225 lb.

TABLE I. RESULT SHEET, 3500-KW. MARSHALLTOWN UNIT

Run No.	Main Pres. lb./sq. in. Gage	Abs. Exh. Pres. in. Hg.	Main Steam Temp. Deg. F.	Temp. above Sat. at 225 lb.	Corrected Weight		Bled Steam Per cent of Total	Total Kw-hr.	Lb. Steam to Turbine per Kw-hr.
					Total Steam Through Throttle Lb.	Steam Bled Lb.			
111	213	.88	545	147	16800			1238	13.46
122	210	1.07	524	126	15900	475	3.0	1249	12.73
105	215	1.00	544	146	21800			1732	12.47
120	208	.99	555	157	21060			1720	12.03
121	208	1.04	546	148	21200	958	4.5	1728	12.11
104	210	1.06	576	178	31550			2641	12.03
110	209	1.10	583	185	31400			2617	11.97
115	207	.77	587	189	32400	2280	7.0	2626	12.35
108	209	1.12	600	202	41700			3280	11.89
116	203	.88	594	196	40700	3540	8.7	3444	11.62
112	212	1.43	558	160	17870	923	5.18	1245	14.30
106	213	1.54	561	163	23750	1463	6.2	1745	13.58
118	205	1.48	602	204	32100			2603	12.24
103	209	1.47	596	198	34100	2270	6.7	2631	13.01
117	198	1.44	603	205	43250			3450	12.36
109	205	1.48	610	212	44500	3160	7.1	2990	12.72
113	210	2.08	569	171	18430	870	4.7	1243	14.76
107	211	2.01	564	166	23860	1070	4.5	1755	13.65
119	206	2.09	576	178	32600			2612	12.45
101	211	1.96	587	189	34900	2325	6.7	2573	13.32
102	209	1.95	597	199	45800	3220	7.0	3085	13.09

gage and with 150 deg. of superheat, corresponding to a total temperature of 548 deg. Cooling is by a closed air system using fin-tube cooling elements. After leaving the hotwell pump, condensate from the main unit condenser passes through the generator air cooler and then goes to the extraction heater.

This heater is a closed feedwater heater, the steam side of which is connected at or near the 11th stage of the turbine; it may be shut off from the turbine by a valve in the steam connection. Condensate, leaving the generator air cooler, passes through the tubes of the heater. A bypass is provided in the condensate line to the heater; on this bypass, a control valve is actuated from the boiler feed line in such a way that if the feedwater temperature goes too high, the heater bypass is opened and no condensate goes through the heater, hence no steam is extracted from the turbine. This control equipment was described in detail in the June 15, 1928 issue of Power Plant Engineering.

Steam condensed in this heater is ordinarily returned to the bottom of the main condenser by a trap but during the tests a reciprocating wet vacuum pump was used, so that the drip could be pumped into weighing tanks.

MEASUREMENT OF CONDENSATE

On the condensate line beyond the stage heater is a venturi meter that measured the condensate, which was then piped to special weighing tanks on a high platform in the turbine room, where it was weighed and then discharged to a surge tank in the basement. Extra head on the condensate pump, caused by the necessary elevation of the weighing tanks, bothered the pump somewhat; during several of the full load runs, the condensate filled up in the condenser to a foot or two above the glass.

Tests for condenser leakage were made by measuring the conductivity of a condensate sample with the dionic tester and comparing it with conductivity of a sample of condensed steam taken from the main. This method of testing for condenser leakage has been found extremely valuable in promptly locating losses in vacuum and all plants of the company are being fitted up with this equipment with the expectation that considerable improvement will be made in operation. Weight of steam used by the turbine steam seals was measured with an orifice.

To hold the exhaust pressure at a predetermined point, the exhaust end of the turbine was tapped for a ¾-in. pipe to admit regulating air, a mercury column being connected near this inlet to indicate any change in pressure. For determining the main steam pressure, a high grade test gage was used. A gasometer measured the air removed from the condenser. Electrical instruments were of a high grade commercial type and were checked before and after the tests. Switchboard watthour meters which had been checked were used to measure the input to the three auxiliary motors.

Each test was for one hour, the operating conditions being held as nearly constant as possible during that time. Readings of mechanical data were taken every five minutes on signal. As the load could not be held constant, wattmeters were read every half minute during each run, while other electrical meters were read at intervals of one to five minutes, depending on the conditions.

RESULTS OF TESTS

Results of the tests are shown in Table I, while averages of all important mechanical data appear in Table II. Weights given in Table II have been corrected for inaccurate scales but not for load, superheat

*Mechanical and Electrical Engineer, Iowa Railway & Light Corp.

and pressure conditions. During most of the tests, an air leak existed in the turbine casing and was not discovered and stopped until the tests were almost finished. This caused some difficulty in getting the exhaust pressure of 1 in. absolute. Before the tests, the leakage was about 8 or 9 c.f.m. but after the tests, when the leaks had been stopped it was about 1 c.f.m.

During all the runs, the conductivity of the steam samples averaged 3 to 4 in most cases, indicating no condenser leakage.

Power factor during the tests varied over a considerable range, although every effort was made to keep it at 0.8. This was caused by imperfect balancing of phases.

Comparison of Tests with Guarantee

On Figs. 1A, 1B and 1C actual test curves have been plotted in comparison with the accompanying guarantee curves for the same exhaust pressure. For 1 in. exhaust pressure, the test curve follows the guarantee curve closely, being slightly lower at one-quarter and half load and slightly higher at three-quarter and full load. One important thing is shown on this curve, namely, that the test results obtained when the bleeder heater was in operation are lower than the non-bleeding points, with one exception. This is contrary to all expectations and would indicate errors in the determination of the lower points. Careful checking of the data, however, fails to reveal any inaccuracy.

Figure 1B shows the results for 1.5 in. exhaust pressure. The only two curves that can be compared are the actual results taken under bleeding conditions and the guarantee, since only two runs were made without the stage heater in use.

Figure 1C gives results for 2 in. exhaust pressure; only one run was made without the bleeder at this pressure. The non-bleeding results on this curve and on that of Fig. 1B indicate that the turbine was operating at or below guarantee results.

In plotting several of the points on these curves, data were taken from a venturi meter in the condensate line in place of actual weight of condensate. Readings of this venturi meter were corrected by comparison with other runs when both venturi readings and actual weights were taken. The reason for using the venturi alone was that during some of the runs, the connections for taking account of the weight of condensate from the steam seal condensers were incorrectly operated, allowing some of this condensate to go direct to the surge tank without being weighed.

Correction of Water Rate from Test

Water rates were corrected to guarantee load, pressure, vacuum and superheat conditions. Guaranteed water rates were plotted for the exact loads and for each vacuum. On these curves was located the actual load for any one test; the difference between the water rates for that load and the guarantee load point was either added to or subtracted from the actual water rate at actual load. If the actual load was below the guarantee point, the correction was subtracted. A similar process was used to reduce the results under actual vacuum to the result under the guaurantee vacuum.

Results were corrected to a temperature of 548 deg.,

TABLE II. AVERAGES OF MECHANICAL DATA TAKEN ON TESTS OF 3500-KW. MARSHALLTOWN TURBINE GENERATOR

Run No.	Bleed or no Bleed	Approx. Load, Kw.	Total Exhaust Lbs. per Hr.	Turbine Exhaust, F. P. B.	Main Steam Lb. per Sq. In.	Vac. Inches Hg.	Pressure: Bar.	Pressure: Abs. Vac. In. Hg.	Pressure: Two-Stage Heater In. Hg.	Steam to Orifice Lb./Sq. In.	Seal From Orifice Lb./Sq. In.	Dis. Cond. Pump Lb./Sq. In.	Cir. Pump: Suction Lb./Sq. In. Pressure	Cir. Pump: Discharge Lb./Sq. In.	Room	Main Steam	Steam to Stage Heater	Condensate: From condenser	Condensate: From Air Cooler	Condensate: From Stage Heater	Bleed from Stage Heater	Circulating Water: Lbs.	Circulating Water: Kilos	R.P.M. Cir. Pump	R.P.M. Air Pump	Venturi Meter Total Lb.	Corrected Weight Lb.*: Main Condensate	Corrected Weight Lb.*: Aux. Bled	Corrected Weight Lb.*: Total Condensate	Condensate Conductivity
111	N.B.	1250	1238	3577	212	28.48	29.36	.86		193	140	17	7.25	28	65	545		65	81		81		42	48	6	985	208	16200	16618		16618	3
122	B.	1250	1249	3567	210	28.09	29.16	1.07	23	207	178	17	7.90	30	79	584	126	75	89	135		120	56	62	6	1173	207	16600	16091	496	16587	3
105	N.B.	1750	1732	3577	215	28.67	29.57	1.00	27	200	68	18	6.60	34	71	544		60	85	86			47	54	7	1155	208	21600	21900x		21900	3
120	N.B.	1750	1720	3575	208	28.25	29.24	.99	27	207	176	18	7.90	30	77	550		75	88	93	145		58	66	8	1169	207	21500	20950		20950	3
121	B.	1750	1722	3572	208	28.15	29.19	1.04	22	206	172	19	7.90	30	78	546	145	75	88	145	134		57	64	7	1157	209	21100	20474	969	21443	3
104	N.B.	2650	2641	3573	210	28.62	29.68	1.04		196	88	21	7.00	34	71	576		74	86	88			49	58	10	1164	208	31500	31600x		31600	3
110	N.B.	2650	2617	3573	209	28.46	29.56	1.10		200	89	21	6.70	34	74	580		75	87	88			50	60	10	1164	206	30800	31183		31183	3
118	B.	2650	2626	3576	207	28.44	29.41	.97	19	191	129	23	6.6	30	71	587	169	70	79	158	142		49	60	11	1173	209	28900	28900	2196	31096	3
108	N.B.	3500	3480	3569	209	28.44	29.56	1.12		199	98	25	6.76	34	73	600		75	85	86			48	58	14	1164	206	37600	28470		28470	3
116	B.	3500	3444	3579	205	28.52	29.40	.88	17	196	148	27	7.75	30	68	594	170	69	78	169	156		51	65	14	1172	209	36400	25403	3386	28819	3
112	B.	1250	1240	3577	212	27.94	29.57	1.43	24	188	118	17	7.25	28	68	558	156	61	81	156	128		43	50	7	985	209	16500	16761	915	17666	3
106	B.	1750	1745	3577	213	29.02	29.86	1.84	22	200	88	19	6.60	34	72	561	148	64	88	147	140		46	54	8	1163		23000	22300x	1463	23763	3
118	B.	2650	2603	3568	205	27.92	29.40	1.46		210	165	21	7.80	30	71	602		62	90	94			56	68	12	1197	209	21200	20921		20921	3
103	B.	2650	2621	3574	209	28.17	29.64	1.47	19	208	172	23	7.00	29	72	596	161	62	90	162	151		48	59	11	1030	207	30600	23000x	2209	23209	3
117	N.B.	3500	3460	3579	198	27.96	29.40	1.44		191	145	25	6.80	30	69	603		62	87	91			54	69	15	1176	209	40800	41416		41416	3
109	B.	3500	2990	3566	205	28.06	29.66	1.46	18	194	86	26	6.70	34	74	610	166	78	90	163	161		49	61	12	1163	206	24500	24358	2630	26988	3
113	B.	1250	1243	3578	210	27.29	29.37	2.08	25	186	114	18	7.20	28	70	569	138	65	93	137	128		45	52	7	985	209	17500	17607	972	18479	2.5
107	B.	1750	1755	3573	211	27.67	29.68	2.01	22	200	88	20	6.60	34	74	564	140	64	89	143	133		46	54	8	1168	207	22100	22400x	1100	24500	3
119	N.B.	2650	2612	3579	206	27.18	29.27	2.09		211	180	22	7.04	30	77	576		68	95	100			50	70	12	1179	210	34000	28649		28649	3
101	B.	2650	2573	3577	211	27.67	29.63	1.96	19	201	99	24	7.25	31	70	587	154	77	88	157	151		43	56	13	1080	208	30900	23200x	2230	25530	3
102	B.	3500	3086	3575	209	27.69	29.63	1.96	17	210	179	27	7.00	29	69	597	169	79	89	169	154		45	59	14	1080	207	36900	26900x	2780	29680	3

* Taken from corrected venturi meter. x Corrected from scale calibration

which is 150 deg. superheat at 225 lb. pressure, by using a correction of 0.8 per cent for each 10 deg. variation from 548 deg.

For pressure correction, 0.64 per cent for each 10 lb. pressure above 225 lb. was added to the approximate water rate and 0.75 per cent was subtracted for each 10 lb. below 225. These corrections were given by the turbine manufacturer.

All corrections were made on the water rate. After determining the total corrected weight of steam through the throttle, it was assumed that anything that would change the amount of steam through the throttle would change the bled steam in the same percentage. Table I shows that the per cent of bled steam varies from 3 per cent under light load to about 8 per cent under full load. This is about what one would expect in a turbine of this type.

In some cases, the corrections are of considerable amount because it was impossible to operate always under the desired conditions. Also, in several of the tests, condensate backed up in the condenser until it was above the gage glass; it appeared to remain at constant level, however, during any one run. These two things may account for some of the slight variations in the results but it is not believed that they are serious.

Low value of field current recorded seems to indicate that the alternator operated with leading current. Efforts were made to check this point when the tests were started; the only explanation that can be offered is that the synchronous condenser in the station was operating with a lagging current at the time and, to permit adjustment of the alternator power factor, this condenser current was increased, which would give a leading current. This error is regretted but it is not believed that it introduces a serious error in the final results, since the losses would be practically the same as with lagging current. There might be a tendency for it to cause slight increase in the water rate especially at full load.

Foregoing tests were conducted by M. P. Cleghorn and F. H. McClain of Iowa State College, Division of Engineering, Ames, Ia.

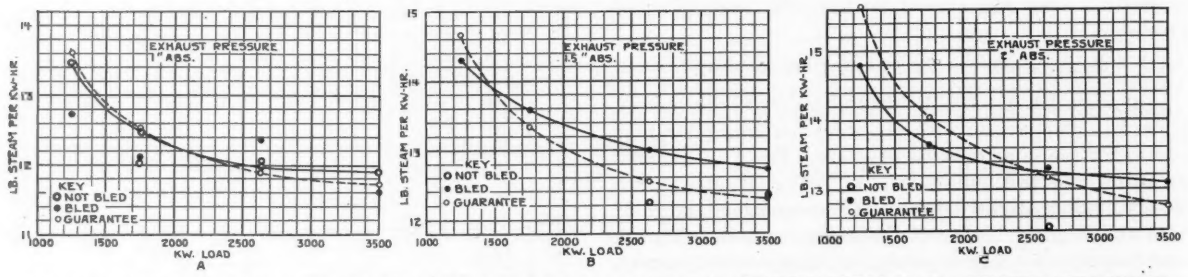


FIG. 1. WATER RATE CURVES FOR 3500-KW. TURBINE GENERATOR, MARSHALLTOWN, IA., TESTED FEBRUARY, 1928. A—EXHAUST PRESSURE 1 IN. ABS. B—EXHAUST PRESSURE 1.5 IN. ABS. C—EXHAUST PRESSURE 2 IN. ABS.

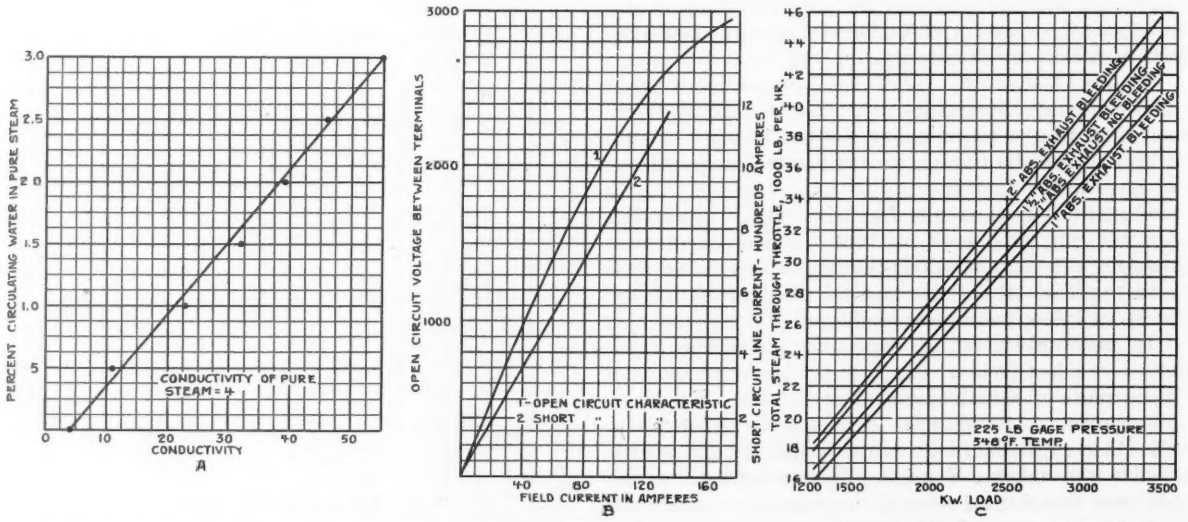


FIG. 2. VARIOUS DATA OBTAINED ON 3500-KW. MARSHALLTOWN TURBINE GENERATOR TEST. A—CURVE FOR DETERMINING CONDENSER LEAKAGE. B—OPEN CIRCUIT AND SHORT CIRCUIT CHARACTERISTICS OF GENERATOR. C—TOTAL STEAM FLOW UNDER VARIOUS CONDITIONS.

USE OF EXTREME high pressures in boilers requires that pure feedwater be used, that riveted joints in drums be avoided, that forgings be homogeneous and free from defects. For superheaters at high temperature, above 750 deg. F., experiments in England have shown that nickel-chromium and chromium alloys of steel withstand the attack of furnace gases and oxidation from steam much better than mild steel.

DISSEMBLERS oftener deceive themselves than others.

Features of 104,000-Kw. Turbine for Crawford

LARGEST UNIT IN PLANT USES LIVE STEAM FOR REHEATING AND EXTRACTS STEAM IN FOUR STAGES FOR FEEDWATER HEATING. BY K. S. KRAMER*

UNIT No. 6, a 104,000-kw. turbine-generator built by the Westinghouse Electric & Manufacturing Co., is now being installed in the Crawford Avenue Station, in Chicago, of the Commonwealth Edison Co. This unit, which is the largest in the station, is of more than passing interest.

Much pioneer work has been done at the Crawford Avenue Station, the first three units to be installed being designed to operate with initial steam conditions of 550 lb. per sq. in. gage pressure and 725 deg. F. temperature, feedwater heating by steam extraction and reheating to 700 deg. by means of special boilers. In the cases of units 5 and 6, the Commonwealth Edison Co. has now turned to reheating by means of live steam in a reheater placed in the turbine room, maintaining, however, the initial conditions of the previous units and also the regenerative process.

This latest addition to the station has, therefore been designed to operate with initial conditions of 550 lb. per sq. in. gage and 725 deg. F. total temperature, intermediate reheating by means of live steam to 500 deg. F. total temperature, feedwater heating by extraction in four stages and to exhaust at a vacuum of 29 in.

STEAM PATH THROUGH UNIT

One of the most appreciable losses in a steam turbine is the leaving loss, or the energy lost in the velocity of the steam leaving the last row of blades. In a unit of this size, an enormous volume of steam passes through the last row of blades, due to the extremely low density, and the choice of steam path was made with a view to reducing this leaving loss to a minimum. The path of the steam is indicated in Fig. 1.

Steam at 550 lb. and 725 deg. is supplied to the high-pressure turbine through which it is expanded to 61 lb. per sq. in. absolute (at a load of 104,000 kw.). From the exhaust of this high-pressure turbine, the steam is conducted to a live steam reheater, where the total temperature is brought up to 500 deg. From here, the steam is led to the intermediate-low-pressure turbine, in which approximately one-third of the steam is expanded down to 29 in. of vacuum in the thrust end, the other two-thirds being expanded down to 12.5 lb. per sq. in. absolute, in the coupling end. From this point, the steam is taken through a receiver pipe to a double-flow, low-pressure turbine, each end of which expands one-half of the remaining steam (or one-third of the total) to 29 in. vacuum.

This novel arrangement, in addition to providing the required low-pressure blade area, has many other advantages, among which are: simplification of design, because of the small size of each section with accompanying low speeds and stresses; minimum temperature range in a given cylinder; rigidity of rotors, and the feasibility of making complete assembly in the manufacturer's shops.

*Engineering Department, Westinghouse Electric & Mfg. Co.

GENERAL ARRANGEMENT OF UNIT

Figure 1 shows an outline of the entire unit. The high-pressure turbine operating at 1800 r.p.m. drives a main generator, an auxiliary generator, and a main generator exciter, arranged in the order named. The main generator has a rating of 44,000 kw. at 85 per cent power factor and produces three-phase, 60-cycle current at 12,800 v. The auxiliary generator has a rating of 4000 kw. at 70 per cent power factor and produces three-phase, 60-cycle current at 2300 v. The main generator exciter is a 150-kw., 250-v., shunt-wound exciter.

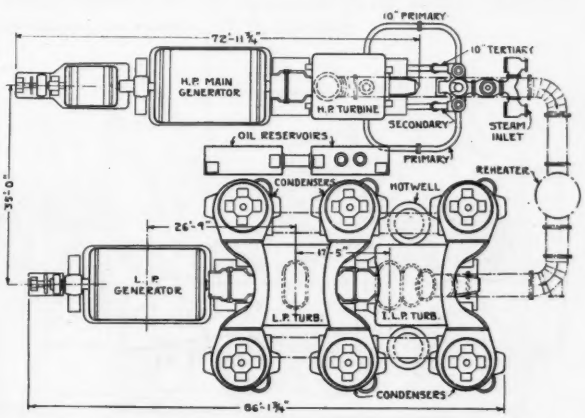


FIG. 1. OUTLINE OF ENTIRE UNIT

The intermediate-low-pressure and the low-pressure turbines are arranged in tandem to run at 1800 r.p.m. and drive a main generator having a rating of 56,000 kw. at 85 per cent power factor, producing three-phase, 60-cycle current at 12,800 v.; and a main generator exciter, shunt-wound, 225 kw. and 250 v.

Overall length of the high-pressure unit is 72 ft., 11¾ in., overall width 13 ft., 8 in., and height 11 ft., 2⅝ in. The corresponding dimensions of the low-pressure unit are length 86 ft. 1¾ in., width 37 ft., 2 in. (including condensers) and height from floorline to top of condensers 15 ft., 1½ in. The total weight of the entire unit, including turbines and generators, is 1050 t.

CONTROL OF STEAM TO TURBINE

Steam is led from the main line through two 14½-in. strainers, a "T" connection with a 20-in. outlet to the throttle valve and steam chest, all of which are placed directly in front of the high-pressure turbine. The steam chest has three valves with specially shaped ports for controlling the steam flow through the turbine, controlled by an hydraulic cylinder mounted on the primary valve. The design is such that the primary valve passes all the steam which goes to the turbine, whether through the primary nozzles or through the secondary or tertiary nozzles.

With this arrangement, in event of accidental sticking of the secondary or tertiary valves, the closing of

the primary will close off all steam to the unit. When operating under the normal or design conditions with four-stage extraction for feedwater heating, the primary valve passes sufficient steam to carry 70,000 kw., the primary and secondary 90,000 kw., and all three valves 104,000 kw. From the steam chest, the steam is led through long flexible inlet pipes, all of which are looped beneath the turbine.

Figure 2 shows a longitudinal section of the high-pressure turbine.

From the nozzle chambers, the steam is expanded through the nozzles, the energy from this expansion being absorbed by a two-row velocity-compounded impulse element. After leaving the impulse element, the steam expands through 21 pairs of rows of reaction blading. Steam is extracted for feedwater heating from the zone between the 14th and 15th pairs of rows and also at the turbine exhaust. The small proportions of this high-pressure turbine are made possible by the cross-compounding scheme adopted, resulting in the low wheel and steam speeds necessary for attendant low windage and friction losses, because of the density of the steam at this high pressure.

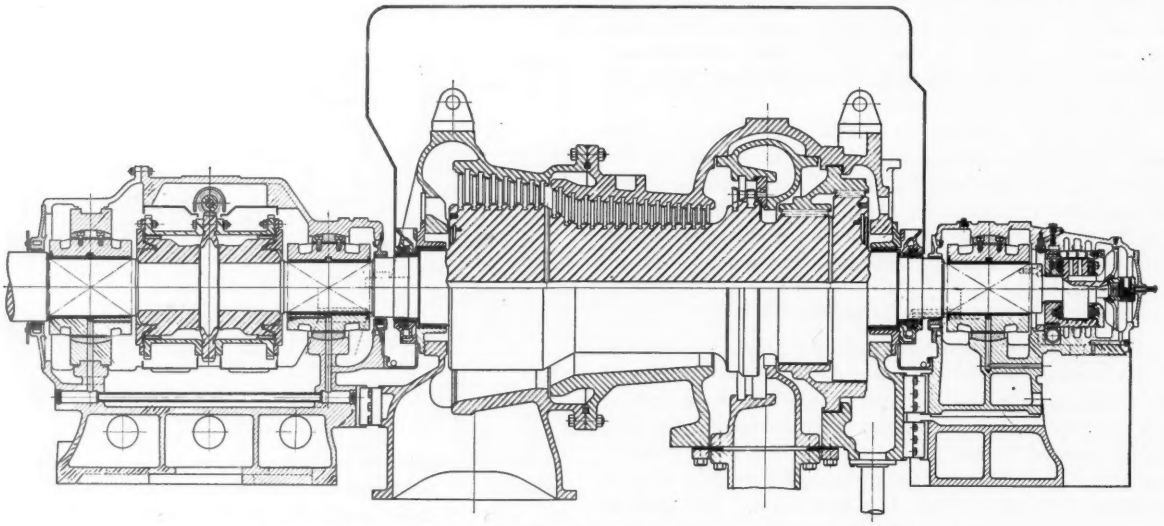


FIG. 2. LONGITUDINAL SECTION OF HIGH-PRESSURE TURBINE

Features of Rotating Element

Thrust towards the coupling end produced by the pressure drop across the reaction blading is counterbalanced by a two-step dummy and a Kingsbury thrust bearing. The loss incurred by reason of the steam leakage through the dummy bypassing the blading is minimized by the use of the two-step dummy and by returning to the blade path from the space between dummies a major portion of the total leakage. The spindle glands consist of a special type labyrinth packing followed by a standard water seal.

Cast steel is used for the cylinder, which is divided vertically into two sections to facilitate casting and machining, the joint being made at the highest bleeder point. All of the cylinder blades are mounted directly in the cylinder wall, while for the dummies a separate ring is employed.

The spindle is a one-piece forging, with an extension bolted to the thrust end. This extension carries the oil governor, pump, thrust bearing and automatic stop governor. An inspection hole 4 in. in diameter was made for the full length of the spindle and a thorough examination of the interior of the spindle forging was made by means of a specially constructed telescope and a combination of prisms.

Blading, both impulse and reaction, is of stainless steel and highly polished. This material is a low-carbon chromium steel, which is highly resistant to corrosion and erosion. The spindle blades are secured with "T" head type roots. The cylinder bore is tapered, rather than stepped, providing a continuous and smooth path for the steam, with resultant higher efficiency because of the absence of eddy losses inherent in the stepped bore construction.

Stresses in all blading have been kept well within safe limit and all blading is lashed with nickel lashing wire to raise the natural frequency of the system and reduce vibratory stresses.

For shut-down periods, a motor-driven turning gear is provided. When the machine is off the line, this turning gear may be used to keep the spindle revolving at a speed just sufficient to prevent spindle deflection due to uneven cooling. With this arrangement, the turbine can be started up quickly and smoothly after any length of shutdown.

Bearings are supplied with oil at 12 lb. per sq. in. gage.

Intermediate-Low-Pressure Turbine

Figure 3 shows the longitudinal sections of the intermediate-low-pressure turbine and the low-pressure turbine. The intermediate-low-pressure turbine is a straight reaction, double-flow turbine, but, as previously stated, with the flow not equally divided. Of the total steam entering from the reheater at 500 deg. total temperature, approximately one-third passes through the thrust end, expanding through 17 pairs of rows of blades down to 29 in. of vacuum. The remaining two-thirds flow through the coupling end expanding

through six pairs of rows of blades to 12.5 lb. per sq. in. absolute at 104,000 kw. load. Steam is extracted for the two lower stages of feedwater heating, from the exhaust at the coupling end and from the zone between the third and fourth pairs of rows on this same end. The last seven pairs of rows on the thrust end are identical to those of the low-pressure turbine.

The cylinder of the intermediate-low-pressure turbine is composed of three sections, a center section and two ends, each section being made up of a cover and base, the thrust end being the same as the corresponding portion of the low-pressure turbine, with minor modifications. As in the high-pressure turbine, all cylinder blades are mounted in the cylinder wall. The center section is made of steel and the two end sections of cast iron. Deflectors are provided at the inlet, for the proper guidance of the steam to the respective ends.

Connecting the outlet from the coupling end to the inlet of the low-pressure turbine is a receiver pipe which is elliptically shaped with an area equivalent to a circular pipe of 6-ft. diameter. Three expansion joints are provided, one at the junction of the receiver pipe and low-pressure cylinder, one at the junction of the receiver pipe and intermediate-low-pressure turbine cylinder, and one in the horizontal portion of the receiver pipe, to allow axial movement between the turbine cylinders. These are of standard copper expansion joint design, with heavy links taking the collapsing forces but allowing the combination of the three joints to act as a flexible unit.

Carbon steel forged in two pieces is used for the spindle, the joint being made between the third and fourth pairs of rows on the coupling end. The main body of the spindle has an 8-in. inspection hole, this being tapered down to 4 in. at each end.

Although the steam flows through the two ends are unequal, the proportions are such that the maximum unbalanced thrust under normal operating conditions causes only a conservative loading on the thrust bearing. One-half of the total steam flow entering the low-pressure turbine passes through each end, expanding through seven pairs of rows of reaction blades to 29 in. vacuum. The cylinder for this turbine is also composed of three sections, a center and two exhaust sections, each part being made up of a cover and base, all three elements being made of cast iron. As in the other two turbines, all cylinder blades are mounted in the cylinder wall. The two exhaust sections (and also the thrust end section of the intermediate-low-pressure) are designed to be connected to vertical condensers, with which type every unit in the Crawford Avenue Station is equipped. Sufficient area is provided through the exhaust end of the turbine from one side of the turbine cylinder to the other, that in case one of the two condensers serving each exhaust end goes out of service, the flow normally taken by this condenser can be taken care of by the other condenser at a reduced vacuum. In addition, there is a 42-in. equalizer pipe connecting all condensers.

Bases of the cylinder exhaust ends are bolted up tightly with a gasket to the condenser, while there is a one-quarter inch gap between the condensers and the covers of the exhaust ends. This gap is covered with a rubber band bolted on by means of flat strips. Removal of the cover is thereby facilitated.

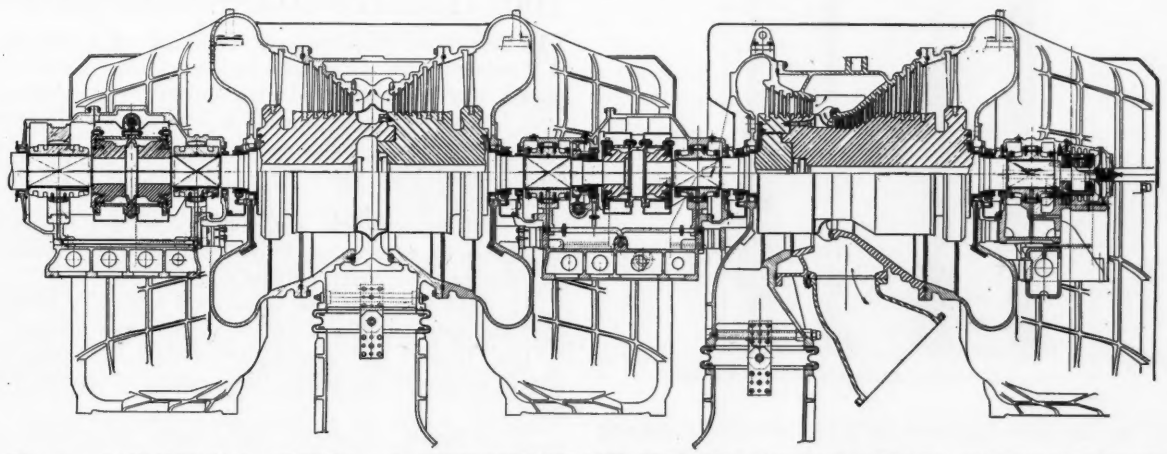


FIG. 3. LONGITUDINAL SECTION OF INTERMEDIATE-LOW-PRESSURE TURBINE AND LOW-PRESSURE TURBINE

The spindle is a two-piece carbon steel forging, with the joint at the center and with inspection holes similar to those of the other two turbines. Although no end thrust exists under normal operating conditions, a thrust bearing is provided for axial location of the spindle.

Glands of both the intermediate-low-pressure and low-pressure turbines consist of several strips of labyrinth packing in conjunction with the standard water seal.

All main bearings are designed for the same limits of pressure and surface speed as given for the high-pressure turbine. A motor-driven turning gear is also provided for this low-pressure element.

Low-Pressure Blading

As in the high-pressure turbine, all rotating blades in both the intermediate-low-pressure and low-pressure turbines are of polished stainless steel, the spindles blades throughout being provided with "T" head type of roots. The last four pairs of low-pressure blades are tapered from tip to base to secure an adequate factor of safety. The inlet edges are warped with an increasing angle from base to tip to receive the incoming steam

tangentially. The lashing wires are located on the centers of gravity of the sections with reënforcements around the holes to restore the full strength to the sections. The centers of gravity of the blade sections are so located with respect to a line radiating from the mean center of gravity of the fastening as to give the least increase in local stress from eccentric loading.

Figure 4 shows the tapering of the section and the warping of the inlet edge.

Governors Are of Oil Impeller Type

There are two governors provided, one on the high pressure and one on the low pressure element. Each governor is of the oil impeller type and in conjunction with an oil ejector serves also as the main oil pump. The arrangement is such that the impeller of the high-pressure governor does all of the governing. The oil is discharged from this impeller at a pressure of 83 lb.

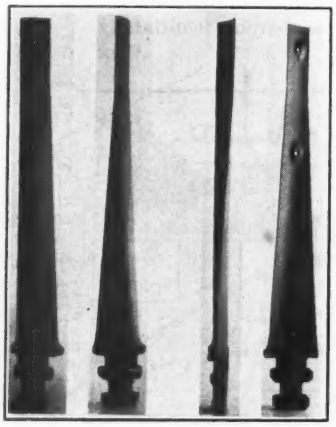


FIG. 4. TAPERING AND WARPING BLADES

per sq. in. operating the relay valve only and supplying through an orifice, approximately one-fourth of the bearing oil. The governor impeller of the low-pressure unit supplies oil at 80 lb. per sq. in. to the operating pistons and through an orifice, the remaining three-fourths of the total bearing oil. There is a line with a check valve from the low-pressure impeller discharge to the governor relay valve, the check valve, during normal operation, preventing oil from the impeller reaching the relay valve due to the difference in discharge pressure of the two impellers. In case the low-pressure element were tripped out by electrical disturbances and started to overspeed, the impeller discharge pressure would increase sufficiently over that of the impeller of the high-pressure element to cause the opening of the check valve. The low-pressure impeller would then control the governing and prevent the low-pressure unit from reaching excessive speeds. The regulation is such as to have all three valves closed with a 4 per cent rise in speed.

In addition to the two main governors, mentioned above, an automatic stop governor is provided on each element. These governors are set to operate at from 10 to 11½ per cent above normal speed and are so arranged that the tripping of either stop will close the high-pressure throttle valve and the three high-pressure governor valves simultaneously.

To insure against overspeeding of the low-pressure element in the event of tube breakage in the reheater, a 4-in. automatic throttle valve is installed in the high-pressure steam line to the reheater. This valve will be closed by the tripping of either the high-pressure or low-pressure automatic stop.

Two auxiliary oil pumps are supplied and are so connected that either pump can supply both turbines. Three oil coolers are provided, two for normal use and one for emergency. Located between the two units are two oil reservoirs, each of 2000 gal. capacity and connected by a pipe from which the oil is led off to the two oil impellers.

This unit combines practically all of the recent means of obtaining reduced steam consumption, high efficiency in the turbine itself, high initial pressure and temperature, feedwater heating by extraction from the turbine and interstage reheating. Every effort has been made to produce a most efficient unit, but with simplification of design and at no sacrifice whatever of reliability.

Tool Hazards to Be Anticipated

WITH KNOWLEDGE of the kind of forces involved, the kind of accident which can be caused may be anticipated and preventive precautions used." This statement is made in a report of the Accident Prevention Committee of the National Electric Light Association which also gives the following list of tool hazards:

I. Cutting and skin abrasion hazards are inherent in the use of adzes, axes, knives, chisels, saws, shovels, etc., due to their sharp cutting edges.

II. Skin abrasions and blisters are caused by roughened and split handles of braces, drills, screw-drivers.

III. Bruises and pinches are caused by hammers, pliers, mushroomed drills, loose heads of percussion tools.

IV. Pinches, punctures and strains are caused by slipping of leverage tools, like screw-drivers, crowbars, pinch bars.

V. Entanglement of clothing with serious resulting accidents may be caused by catching on moving parts of machine tools.

VI. Crushing of members is common in use of rollers, slings, skids, cranes.

VII. Punctures are often due to tools with tangs used improperly without handles.

VIII. Burns are caused by careless use of furnaces, forges, torches, solder pots and irons.

IX. Bruises caused by dropped hand tools are common because of careless work on scaffolds, ladders, poles and step-ladders.

X. Falls from scaffolds and ladders are due to insecure supports, footings, rails and defective ladders.

XI. Tripping is frequently caused by hand tools, rollers, snakes, ropes, etc., lying loose on walkways.

XII. Eyestrain, insufficient vision due to intense glare, or inadequate lighting causes trips, falls and other mishaps.

XIII. Electric shock due to grounds in portable tools is much too prevalent. At the 1926 National Safety Congress in Detroit, over 75 fatal low voltage shocks were reported, many of them in the use of portable tools.

Burning Characteristics of Different Coals

FROM THE OPERATOR'S STANDPOINT VARIOUS COALS CAN BE GROUPED IN FOUR CLASSES ACCORDING TO THEIR BURNING CHARACTERISTICS. BY HENRY KREISINGER[1] AND B. J. CROSS[1]

VARIOUS AMERICAN coals have particular burning characteristics which differ according to the geological age of the coal, its chemical composition, physical structure, moisture content, and size. The American coals cover a wide range of geological age. They include the graphitic coal of Rhode Island, the anthracite coal of Pennsylvania, Colorado, and Arkansas, the low-volatile coals represented by Pocahontas and New River, the high-volatile coals of the Appalachian coal field, the high-volatile coals of the Illinois coal field, the coals from the bituminous-coal fields starting in Arkansas and running through Oklahoma, Kansas, and Missouri into Iowa, and the various small Western coal fields containing small amounts of high-grade bituminous coal as well as sub-bituminous coal, and the Texas and North Dakota lignite.

GEOLOGICAL AGE OF FUELS AND COAL AS SHOWN BY CARBON, HYDROGEN, AND OXYGEN CONTENTS

Coals are formed from woody plants by natural processes of carbonization. As the process of carbonization progressed the percentage of oxygen decreased and that of the carbon increased. The oxygen content in the coal is therefore a good indicator of the stage of the process of formation of coal.

This relation between the age of coal and the oxygen content is shown in the accompanying diagram, which is a transcription of a chart compiled by Ralston and published in Technical Paper 93 of the United States Bureau of Mines. In Ralston's chart thousands of analyses of coals, lignites, and other fuels are plotted on trilinear coördinates representing the carbon, hydrogen, and oxygen contents of moisture-free, ash-free, nitrogen-free, and sulphur free coal. That is, the coal is assumed to consist of only carbon, hydrogen, and oxygen, containing none of the oxygen and hydrogen which can be driven away as moisture.

In the chart the triangle represents the trilinear diagram with each of the three coördinates running from 0 to 100. The horizontal distances are the percentages of carbon, starting at the right and ending with 100 per cent at the left-hand corner. The vertical distances are the percentages of hydrogen, beginning at the bottom and ending with 100 per cent at the upper corner. The oxygen begins with the slanting side of the triangle as zero and runs toward the lower right-hand corner as 100 per cent. Any point within this triangle represents a definite proportion of these three variables. The perpendicular distance of such a point from each of the three sides will represent the percentage of the respective constituent.

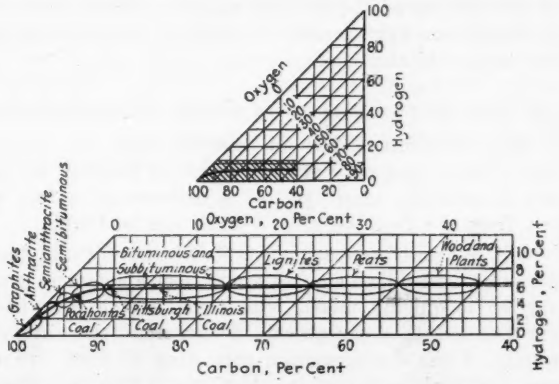
The striking feature of the chart is the fact that, starting with wood, the oxygen content is about 42 per cent. It gradually decreases through the peats, the lignites, sub-bituminous, bituminous, semi-bituminous, and anthracite coal to less than 2.5 per cent.

[1]Combustion Engineering Corp. Abstract of a paper presented before the Second National Fuels Meeting of the A. S. M. E.

GROUPING OF COAL ACCORDING TO BURNING CHARACTERISTICS IN THE FUEL BED

The various coals can be arranged into four groups according to their burning characteristics in the fuel bed, as follows:

1. Coal that retains the original size and shape when heated. The process of combustion proceeds on the surface of the individual pieces of coal, and the pieces are gradually reduced in size until completely burned. Throughout the process of combustion the fuel bed remains fairly homogeneous as to the aggregation of the coal pieces, and there is but little tendency for the air to channel through. The graphitic coal of Rhode Island,



CHARACTERISTICS OF FUELS AND THEIR RELATIONS AS SHOWN BY RALSTON'S CHART

the Pennsylvania, and the Colorado anthracite coals are representative of this group.

2. Coals that soften and become sticky when heated. The individual pieces lose their shape and fuse into a mat or masses of coke. These masses of coke crack or are broken by the agitation of fuel bed when burned on the underfeed type of stoker. The cracks burn out into fissures or channels, allowing the air to flow freely, while no air may pass through the mass of coke. The Pocahontas, the New River, and most of the bituminous coals in the Appalachian coal field belong to this group.

3. Coals that do not soften and become pasty to a sufficient extent to stick together to form mass of coke, but tend to burn as individual pieces, retaining more or less their original shape. The fuel bed retains nearly uniform aggregation of the pieces, and air passes through the fuel bed without marked channeling, and combustion is nearly uniform over the grate. Illinois coal and most of the Western bituminous coals belong to this group.

4. Coals that do not fuse but change their shape and size when heated. The individual coal pieces first expand and crack, and then small pieces break off. The lumps are gradually disintegrated into small flakes ⅛ to ¼ in. across. If the pressure of air under the grate is too high, the smaller pieces may be blown out of the fuel bed and may be carried out of the furnace.

Most of the Western sub-bituminous coals and lignite belong to this group.

Some of the coals show a peculiar behavior when heated. The individual pieces become soft under the surface without the surface becoming sticky. The gases generated inside the pieces produce sufficient pressure to expand the pieces into fantastic shapes; they frequently resemble the bodies of large insects. The surface of the pieces is greatly enlarged and when the expansion ceases, the resulting shapes become brittle and break into small pieces even with the slightest agitation of the fuel bed. Alaska Bering River coal behaves in this manner.

Characteristics of the Flame

Characteristics of the flame are affected by the composition of gases rising from the fuel bed and the manner in which oxygen is supplied for their combustion. The gases consist not only of those formed by the interaction of oxygen and the carbon, but also of products of distillation of the volatile matter. These products of distillation vary greatly in composition according to the nature of the coal.

Hydrocarbons Unstable at Furnace Temperature

Hydrocarbons either in gaseous form or as tar vapors are found only at the surface of the fuel bed in any measurable quantity. At a distance of a foot or two from the fuel bed only a trace can be found.

All hydrocarbons are unstable at the furnace temperature, and unless enough air to insure complete combustion is quickly mixed with them at the time they are distilled, they are quickly decomposed, the ultimate results of the decomposition consisting of soot, hydrogen, and carbon monoxide. Methane, which is perhaps the most stable hydrocarbon, is found in traces at a distance of 2 ft. above the fuel bed.

Soot is formed at the surface of the fuel bed by heating the hydrocarbons in deficient air supply. It is not formed by the hydrocarbon gases striking the cooling surfaces of the boilers. As a matter of fact only a very small trace of the hydrocarbons ever reaches the surface of the boiler; hydrocarbons that do so are prevented from decomposition by the cooling effect of the contact. The cooling surfaces do not cause the formation of soot; they merely collect it. The soot particles are burned with difficulty because the carbon molecule is made up of a large number of atoms, probably 12, therefore it would require 12 oxygen molecules for complete combustion. When burning high-volatile-matter bituminous coals, air should be supplied as close to the surface of the fuel bed as possible so the heavy hydrocarbons may be burned directly without the formation of soot.

Comparison of Processes of Combustion in Fuel-Bed and in Powdered-Coal Furnaces

Processes of combustion in a hand-fired furnace lend themselves well to study. The composition and temperature of gases at any stage of the process may easily be determined. Such a study has been made by the United States Bureau of Mines, the results of which appear in Technical Paper 207. A similar exhaustive study of combustion of coal burned in powdered form is more difficult and has not yet been made. It is, however, possible to draw some inferences and to apply some of the results of the study of the experimental hand-fired furnace to combustion in a powdered-coal furnace.

For purposes of comparison we may assume that the atmosphere in a powdered-coal furnace is a fuel bed of very open structure. Instead of voids of about one-third the fuel volume that we have in the hand-fired fuel bed, we have a void space of about 60,000 times the size of the coal particles. Also instead of the high relative velocity between the stationary coal and the moving air we have a very low relative velocity as the coal particle and the air are moving at almost the same speed and in the same direction. These differences in densities of fuel and relative velocity should have a very marked effect on the processes of combustion.

In hand-fired furnace experiments the limit of the amount of air that could be passed through the fuel bed was between 6 and 7 lb. per lb. of coal burned. Any attempts to increase this amount simply gasified more coal and the ratio of coal to air remained the same. The balance of the air required had to be supplied over the fuel bed. In the powdered coal there is no such limit. Any amount of air can be introduced with the coal. There is a slight advantage in favor of powdered coal burning in this respect as the coal particle can be surrounded with enough air for its complete combustion.

When coal is burned on grates the rate of combustion varies directly with the rate of passing air through the fuel bed; that is, it varies directly with the velocity of the air past the fuel or the relative velocity. This analogy must also hold for the combustion of powdered coal. To get higher rates of combustion we must get higher relative velocity between the coal particle and the air. Increasing the amount of air supply will accelerate combustion. A large excess of air in the furnace, however, is a poor substitute for mixing and is undesirable as it increases the dry gas losses usually at a higher rate than it reduces the losses due to unburned carbon.

Combustion of Volatile Matter in Powdered Coal

When coal is burned in pulverized form, the coal particles are surrounded with air and the distillation of volatile matter takes place, at least partly, in presence of oxygen, and some of the distilled tar vapors are burned directly, while others are first broken into soot and permanent gases and then burned. The proportion of tar vapors burning directly depends on the amount of air supplied with the coal and the initial intensity of mixing. When all the air needed for the combustion of volatile matter is supplied with the coal and the mixing is intensive, the volatile matter burns quickly and the visible flame is short. If only a small amount of air is supplied with the coal and the mixing is slow, most of the distilled tars break into soot and permanent gases and the visible flame is long.

During the process of combustion of the volatile matter, the distilled tars and gases diffuse into the surrounding air, as well as the air diffusing to the surface of the coal particle. For this reason, the combustion of volatile matter takes place faster than the combustion of the fixed carbon. Therefore, coal having a high per-

centage of volatile matter will burn faster than coals with high fixed carbon. Although the high-fixed-carbon coals may have a short visible flame a large part of the fixed carbon must be burned beyond the tips of the visible flame, and space must be provided for its combustion. A short visible flame is not always an indication of good combustion, especially if the coal burned has a low volatile-matter content.

Burning Coking Coals in Pulverized Form

When heated, the coking coals of the Appalachian field become soft and the pieces fuse and form a crust or a mass of coke. This characteristic is commonly observed when the coal is burned in hand or stoker-fired furnaces. Such fusion of particles undoubtedly takes place with these coals when burned in pulverized form, especially when the mixture is dense. The particles collide while in the plastic stage and fuse into larger particles having less surface for the action of oxygen. These large particles may pass through the furnace only partly burned. Frequently particles of coke are found in the flue dust that are considerably larger in mass than the particles of coal originally fed to the furnace. When these coking coals are burned in powdered form, the flue dust invariably contains a larger percentage of carbon than the flue dust from free-burning coals.

Another cause of this higher combustible in flue dust may be a lower reactivity of the fixed carbon with oxygen. When oxygen comes in contact with fixed carbon, the products of combustion may be largely CO_2, whereas with the free-burning non-coking coals a greater part of the products of combustion may be CO_2 which diffuses into the furnace atmosphere and easily finds the small amount of oxygen that it needs to burn to CO_2; thus, the process of reducing the fixed carbon to gas in the Eastern coking coals may be slower than with the free-burning coals. These coals may also make smoke if enough air is not supplied with the coal to burn the volatile matter and when the mixing during the process of distillation is slow.

Burning Free-Burning Coal in Pulverized Form

Free-burning bituminous coal, such as Illinois coal when heated under ordinary furnace conditions, does not become sticky and fuse. The coal burns as individual pieces both on the grate and in pulverized form. The coal has a high volatile-matter content which is driven off mostly as gas, leaving a comparatively small amount of the combustible to be burned as fixed carbon. The length of the visible flame depends on the amount of air supplied with the coal and the intensity of mixing. Generally speaking, it is about the same length as with the Eastern high-volatile coals and longer than with the low-volatile Eastern coals.

When burning sub-bituminous coals and lignites in pulverized form, the particles of coal not only do not fuse into larger pieces, but may actually be disintegrated into small pieces as they do on grates. The rapid heating of the pulverized-coal particles greatly favors such disintegration. Thus, the average-size particle of 1/400 in. may be split into a large number of much smaller particles with several times the surface of the original particle. The flue dust resulting from burning pulverized lignites usually contains less than 2 per cent combustible, and never contains large pieces of carbon such as the flue dust from burning coking coals contains. The flame is somewhat shorter than with Illinois coal and not inclined to smoke.

Fusibility of Ash

Fusibility of the ash affects the combustion, but there is no relation with the composition of the coal or with its geological age. The fusibility of the ash varies with the different beds and even with different locations of the same bed.

Burned-out ash from coal is a non-homogeneous mixture which does not have a definite melting point. It is composed chiefly of compounds of silica, alumina, iron, and lime. The fusion temperature of the mixture is always lower than the melting point of the individual constituents and cannot be predicted from the analysis of the ash.

Speed Reducers and Variators in Power Plants

Variety and Number of Uses of Speed Reducers in Power Plants Increasing. Factors Determining Selection and Analysis of Different Types

EXTENSIVE USE of high-speed drives for motive-power in power plants such as electric motors and steam turbines, particularly of the impulse type, brought about the problem of selecting a reduction unit which would reduce this high speed to a usable one without loss of any of the advantages gained by employment of the faster motive power.

Perfection of power plant operation and consequent increase of control applications have also led to adoption of speed changing devices to many kinds of auxiliary power equipment so that today speed reducers are employed in the operation of stokers, pumps, hoists, cranes, conveyors, coal crushers, ash discharge rolls and exciters as well as serving to connect prime movers to their driven units of whatever class.

Reversing the process has recently been resorted to with success. Speed increasers have been used for geared connection between Diesel engines and deep well turbine pumps. In this case, the engine may operate at 800 r.p.m. and drive the pump at 1800 r.p.m. The gain secured by this device over the former method of quarter-turn belt drive is not only compactness of the installation but also approximately 25 per cent in installed cost. Similar application has been made in the case of Diesel-driven, high-speed blowers.

Omitting electrical drives, speed reducers in the broader sense, may be classified as follows into types and sub-types: belt drives, under which we would have the band belt with idler pulley, rope drives, chain drives and V-belt drives; gear reducers, under which we should consider spur, worm herringbone and planetary gear reducers; friction reducers and hydraulic or fluid action reducers. These various sub-types are illustrated in Figs. 1 and 4.

Selection of Type Involves Many Factors

Great variation of requirements exists and no one type fills all needs. Selection, therefore, should be made after careful consideration of the following qualities in relation to the particular requirements in each specific case. These qualities are not enumerated in the order of their importance, since this order will depend upon specific requirements. The principal qualities to consider are: safety, compactness, reliability, initial cost, depreciation, upkeep, attendance, non-reversibility, accessibility, protection from dust and oil, convenience of application, efficiency, power transmitting capacity, quietness of operation, rigidity, smoothness of torque transmission, speed limit, speed rates, and relative position of driver and driven part, that is, whether the drive is to be parallel, at right angles or at some other angle.

Where shock is not present and extreme smoothness of operation is not essential, the spur gear reducer is used extensively when medium tooth pressures and low speed conditions prevail. In the case of an overhung load on an extended shaft, excessive leverage may produce overheating and wear but these effects can be readily avoided by use of an outboard bearing. Allowable speeds of operation are much lower in this and the planetary type, which comprises spur gear construction, than is the case with the other types. Care should be taken in each case to keep within the limit of the speed recommended by the manufacturer. Spur gear reducers produce parallel reduction. If the power is to be taken off at a right angle, a combination of types may be resorted to as shown at D, Fig. 1. Because of the greater number of teeth in contact, the planetary type has an advantage over the spur type where smoothness of operation is desirable. This type is also exceedingly compact, as will be seen at I, Fig. 1.

Shock Avoided by Gradual and Multi Contact

Shock is avoided in gearing by the use of helical teeth which, in speed reducers, are made with opposing angles or of herringbone form in order to balance the end thrust due to the angular contact. To simplify production and to avoid possibility of foreign matter clogging up the apexes of the teeth, some manufacturers construct their gears with a groove between the two twisted portions as shown at H in Fig. 1. Another way of accomplishing this purpose, particularly in large gears, is to stagger the teeth as shown in Fig. 1 at F in which case the width of the mechanism has not been increased by the interposition of a groove. Where gears of this type are protected and run in a bath of oil or otherwise thoroughly lubricated, the liability of the apexes to clog is remote.

Overall dimensions of gears and housings of herringbone gear reducers are somewhat greater than those of the spur gear type, due to the parallel operation of the two shafts and because the pinion and gear in the former type have only one contact while the latter has

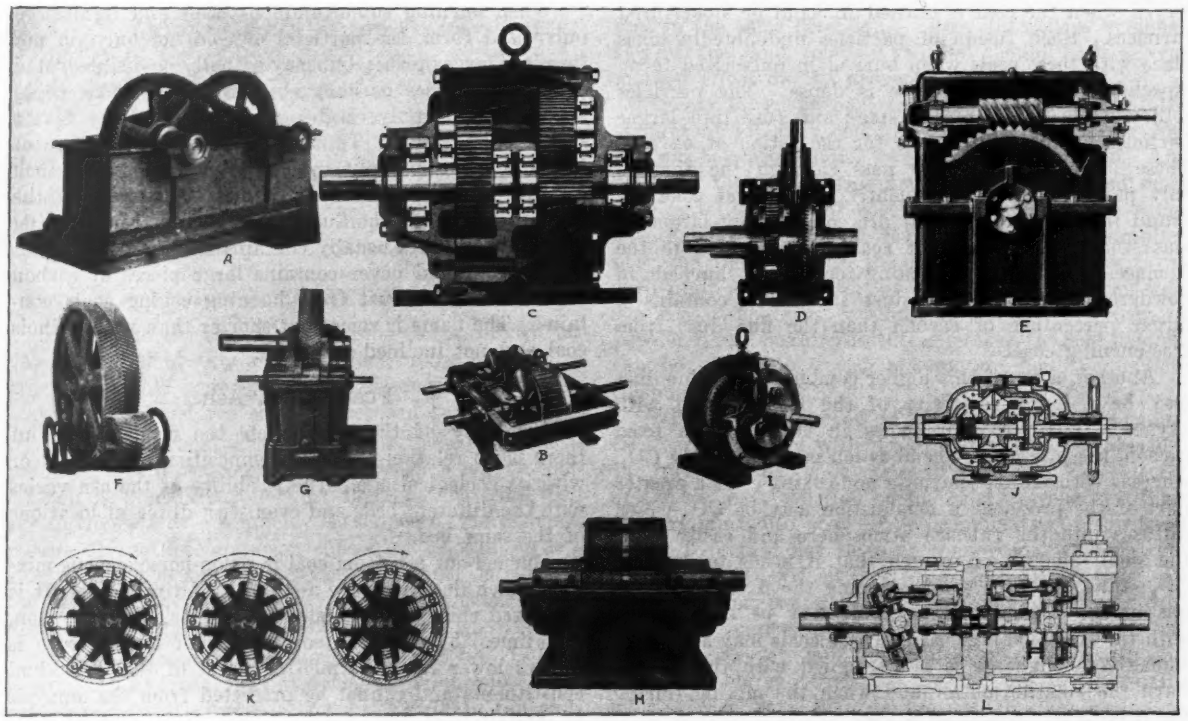


FIG. 1. TYPES OF SPEED REDUCERS AND VARIABLE SPEED TRANSMISSION

A. Double reduction chain gear reducer.
B. V-belt variable speed transmission.
C. Spur gear reducer with roller bearings.
D. Reducer with combination of spur and bevel gear drives.
E. Overlining worm gear reducer with roller thrust bearings.
F. Herringbone gears with staggered teeth. Wheel is 16 ft. diam., 40 in. face and weights 45 t.
G. Triple reduction herringbone gear reducer with both separate helical sets and continuous-tooth gear.
H. Herringbone set with groove separating right and left-hand members.
I. Planetary gear reducer.
J. Friction cone roller variable speed transmission gear.
K. Pump for hydraulic variable speed control.
L. Motor for hydraulic variable speed control.

several. Use of smaller gears and finer pitches, however, overcomes this objection.

Speed ratios of 8000 to 1 have been attained by one herringbone gear reducer and as high as 5000 r.p.m. has been secured by another reducer of this type while as much as 22,500 hp. has been transmitted through a third example.

Worm gear reducers also have the advantages of compactness and avoidance of shock and are frequently used in combination with other systems of gears. Ordinarily, the power is delivered at a right angle to the driver but, in special cases, as where inclined teeth are used, it may be delivered at any desirable angle. Thrust in one direction, depending upon the direction of rotation, always exists in a worm gear construction but detrimental effect is avoided by the use of roller or ball thrust bearings

Application of Ball and Roller Bearings

Advantages to be gained by the use of ball and roller bearings in this connection are that the starting load

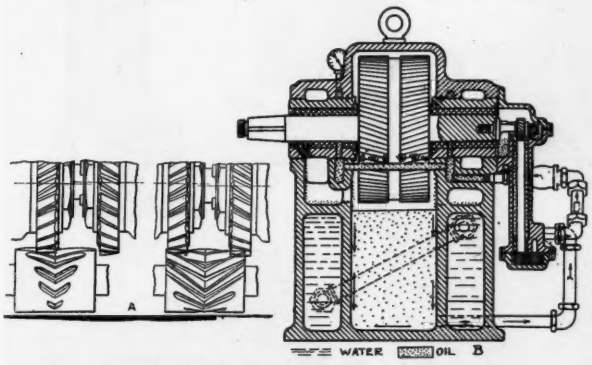


FIG. 2. DESIGN FEATURES OF HERRINGBONE GEARS

A. Illustration of method of generating continuous toothed herringbone gears.
B. Spray lubrication and water cooling used on herringbone gear reducer.

of ball bearings is practically the same as the running load while the starting load of plain bearings is in many cases as much as 100 per cent greater than the running load.

The life of a plain bearing is only a fraction of the life of a ball bearing when rigidity and alinement of the rotating members are considered. Non-rigid shafts accelerate the breaking down of bearings because of crystallization, due to numerous sharp blows and the shearing stress caused by mis-alinement when the load is put on the ends of the teeth instead of across the entire face.

Churning Action of Lubricant Causes Heating

Overhung worm types are considered to be better than underhung types for steady service under heavy load because the former heat up less, since the latter usually work in a bath of heavy oil which in time becomes heated, due to churning action.

Worm gear reducers, when suitably housed, will run in any position, vertical as well as horizontal. This mechanism is usually non-reversible. On a plain-bearing worm gear reducer, it is safe to assume self-locking when the lead angle of the worm thread is 6 deg. or less.

High speed ratios are available by compounding or tripling the reductions as shown at D in Fig. 4 and at G in Fig. 1. A speed ratio of 10,000 to 1 has been secured by one worm gear reducer and a speed of 2000 r.p.m. has been attained by another of this type still another transmitted 500 hp. Flexible couplings are used in connection with geared reducers to relieve the bearings of strains and thrusts due to springing of bed plate or expansion from heat, as well as to compensate for slight misalinement.

Accuracy and Care in Manufacturing

Great care in tooth design and specially designed manufacturing tools have resulted in extreme accuracy

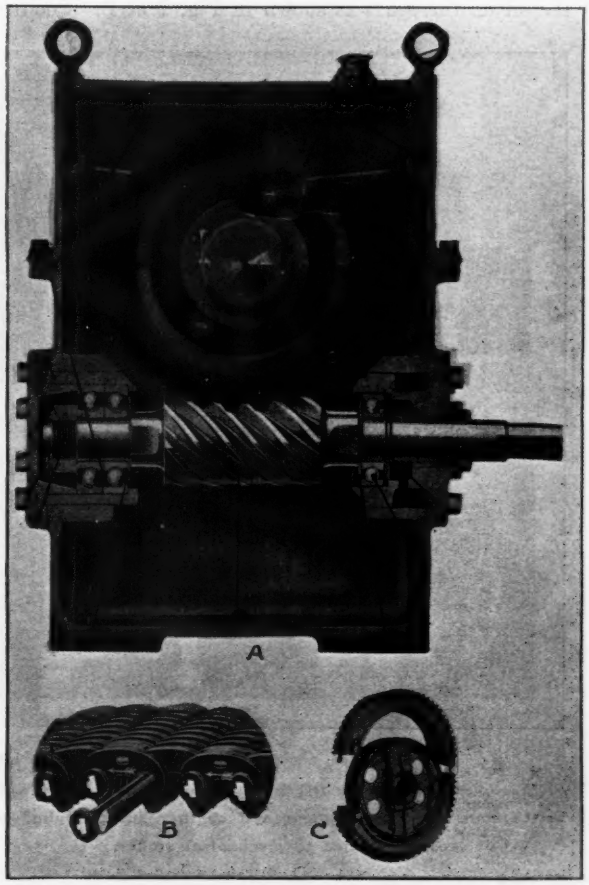


FIG. 3. DETAILS OF SPEED REDUCER CONSTRUCTION

A. Pressure lubrication and ball thrust bearings reduce friction in worm gear reducer.
B. Rocker joint specially shaped links keep chain in proper pitch contact.
C. Compensating spring sprocket used on chain reducers for shock loads.

in the production of gears and great increase in the efficiency of their operation by changing all sliding friction into rolling friction. Worms and gears are now "run in" on special relieving machines to insure smooth and efficient action. Special metals such as phosphor-bronze for gears and special alloy steels for worms are used and many manufacturers employ special heat treatments in order to obtain requisite strength as well as wearing qualities. Tooth faces are finished by grinding.

Generation of teeth of herringbone gears is carried

on by one manufacturer in the manner indicated at A, Fig. 2. Both cutters are mounted on one reciprocating carriage and their position adjusted so that each cutter will end its stroke when its cutting edges are at the center of the blank face, one cutter being on its cutting stroke while the other is returning, making the cutting continuous. The blank and cutters revolve so that the teeth are generated by a series of tangents, the apexes being automatically cleared out as the teeth move out of engagement, due to the depth of cut decreasing to an infinitely small amount.

Proper lubrication of gearing is highly important. Some manufacturers have their gears dip in a bath of oil, forced lubrication for bearings is used by some, and others use ring oilers. One omits oil rings and sprays the oil on the gears as shown in Fig. 2 at B. Cooling

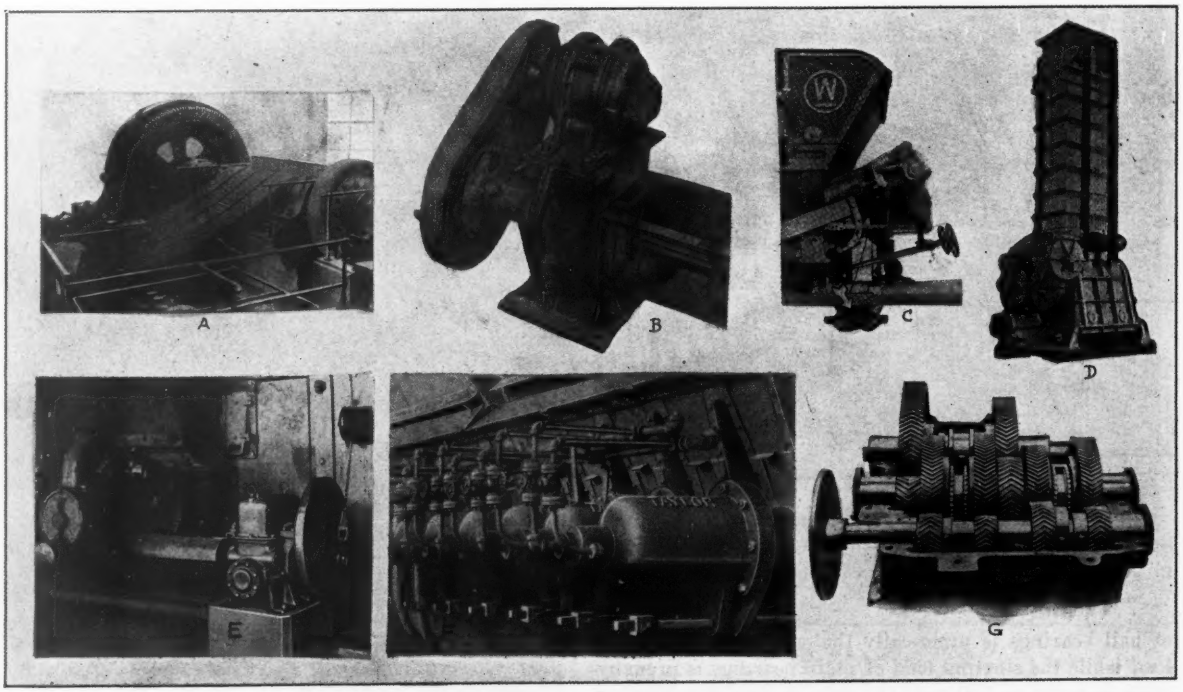


FIG. 4. APPLICATIONS OF SPEED REDUCERS TO POWER PLANT MACHINERY

A. 500-hp. chain speed increaser connecting water wheel with generator.
B. Combination of spur gear and chain reducer applied to screw conveyor.
C. V-belt reducer applied to mechanical stoker.
D. Combination of spur gear and worm gear reductions totaling a 35,000 to 1 ratio.
E. Speed reducer connected to mechanical stoker.
F. Hydraulic variable speed.
G. Eight change-speed reducer box.

of the lubricating oil by means of water circulation is also illustrated in this figure. One manufacturer accomplishes this cooling by immersing a cooling coil of seamless copper tubing in the lubricating oil reservoir which is located in the base of the reducer.

Means to prevent oil leakage at the bearings are usually adopted. One of these employs annular rings surrounding the shaft near the outer end of the bearing, which rotate with the shaft. Pockets in the casing such as shown at B, Fig. 2, and A, Fig. 3, drain the splashed lubricant back to bearings or gears.

Reducers of the chain belt type operate at as high as 6000 r.p.m. and transmit as much as 5000 hp. One manufacturer has a reducer of this type which operates on a 40 to 1 speed ratio. A detail of the construction of one of these chains is shown at B, Fig. 3, in which the rocker joint and chain construction are such as to keep the chain always in proper pitch contact with the sprockets, maintaining a distribution of the load over a large number of teeth.

Two parallel shafts each of which carries a pair of cone-faced disks, mounted with apexes facing, over which runs a special V-shaped belt fitting the throat formed by the disks, represents another type of reducer B in Fig. 1. Speed ratios as high as 16 to 1 and speeds of 600 r.p.m. have been obtained by means of this type of reducer. The amount of power transmitted is comparatively small reaching about 150 hp. Remote control has been adapted to this type of reducer through electrical connection and push button operation.

Another speed reducer that supplies a minute gradation of speeds consists essentially of three rollers which roll around the outside of two inner races and around the inside of two outer races. The inner races are rotated by the input or constant speed shaft as shown in Fig. 1-J while the outer races are stationary. The rollers are, therefore, caused to move in planetary fashion about the axis of the machine and at a slower speed than that of the inner races. The speed change is effected by moving the outer and inner races.

Hydraulic variable speed gears have recently been applied to power plants as illustrated in Fig. 4-F. Oil is the medium used for transmitting energy. The transmission mechanism consists of two units, a pump such as illustrated in Fig. 1-K and a motor Fig. 1-L. Speed change is accomplished by shifting a lever which changes the position of a floating ring as shown at K, increasing or decreasing the stroke of the pump.

Practical Drumless Boiler May Be Developed

NOBODY CAN SAY WHAT THE ULTIMATE SOLUTION OF THE BOILER PROBLEM WILL BE SHOULD DRUMLESS BOILERS COME INTO USE FOR HIGH PRESSURES

USE OF HIGHER and higher steam pressures led many of the boiler manufacturers to make experiments. Among the most interesting of these experiments were those performed by the Babcock & Wilcox Co., at Bayonne Plant, on what it terms "series boilers" and "drumless boilers."

During the World Power Conference in 1924, the series boiler shown in Fig. 1 was described and at that time it was stated that a drumless boiler was being tested, this drumless boiler being the steaming economizer part of the arrangement mentioned.

Recently Dr. D. S. Jacobus, advisory engineer of the above-mentioned company, discussed possibilities of series and drumless boilers before the Engineers' Society of Western Pennsylvania. He stated that the series boiler shown in Fig. 1 was one of the steps in the development of the Calumet boiler* and that the

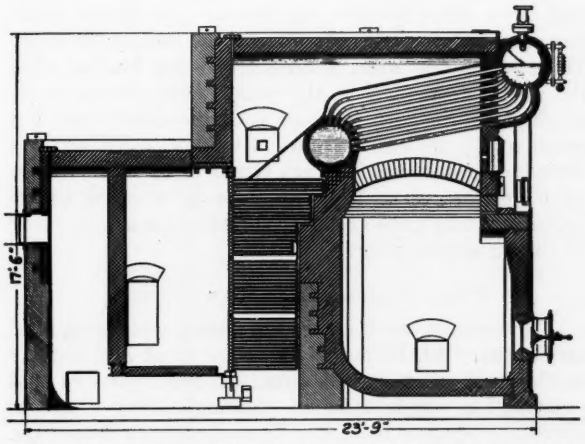


FIG. 1. ONE OF THE BOILERS USED IN THE TESTS LEADING UP TO THE DEVELOPMENT OF THE CALUMET BOILER

use of higher pressures had led the company to make experiments on a drumless boiler provided with forced circulation.

Constructed over 10 yr. ago, the name "series boiler" was applied to the first of this type tested which had no steam and no water drums. The second one tested employed the use of a small natural circulation boiler having steam and water drum as shown in Fig. 1. The natural circulation unit was made up of 2-in. tubes and the steaming economizer of 1-in. tubes, the surface of the economizer being 3.7 times that of the heating surface of the boiler.

Surfaces were small, the boiler having 187 sq. ft. of tube surface, 51 sq. ft. of superheater surface and 685 sq. ft. of surface in the steaming economizer element. The boiler was fired with fuel oil and operating at 600 lb. gage pressure, was run at times to evaporate over 15 lb. of water per sq. ft. of total boiler and economizer surface.

*See Power Plant Engineering, June 15, 1928, page 687 and July 15, 1928, page 765.

All parts were found to operate in an entirely satisfactory way. The rate of evaporation of the natural circulation boiler with 2-in. tubes was about 45 lb. of water per hour per square foot of heating surface in a high capacity test. Comparing Fig. 1 and the Calumet boiler,* it will be seen that there is a decided similarity between them, in that the single-pass boiler

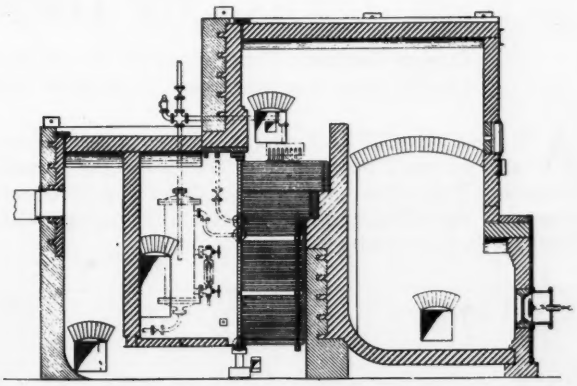


FIG. 2. THIS BOILER, UPON WHICH EXTENSIVE TESTS WERE MADE, HAS NO DRUMS BUT CONSISTS OF THE ECONOMIZER PART OF THE BOILER SHOWN IN FIG. 1

with natural circulation is placed directly above the furnace in each case and the water is fed through a steaming economizer. The main distinction in the Calumet boiler is in the use of the Bailey furnace wall construction.

Often the question is raised as to whether it would not be possible to develop a drumless boiler for high pressures. Experiments were carried on along this line and the drumless boiler and furnace shown in Fig. 2 was tested. A portion of the arrangement in this figure shown in dotted lines is diagrammatic, although the actual arrangement used follows in all its essential features the diagrammatic arrangement.

SEPARATOR USED BETWEEN BOILER AND SUPERHEATER ELEMENTS

Feedwater was fed continuously to the boiler, first passing through the tubes, which acted as an economizer and then to the tubes in which steam was formed. The steam with some excess water was then passed through a separator fitted with a gage glass and drain. The water was drained continuously from the separator and the rate at which the boiler was fed was adjusted so as to hold the height of the water in the gage glass within a given range. Steam from the separator passed through a superheater placed so that there were 17 rows of drumless boiler tubes between it and the furnace.

There was no trouble with the operation of the boiler, which was run at from 600 to 650 lb. working pressure for a maximum of about 500 per cent rating, based upon the entire surface including that part act-

ing as an economizer. There was trouble with the brick work in the oil fired furnace but with a water cooled furnace, this difficulty would disappear and a boiler of this sort might successfully be used for certain classes of work.

In the series boilers which were tested, the following elements were embodied: First, they were arranged to have comparatively no frictional resistance to flow of steam and water, this amounting to about 20 lb. per sq. in. in the boiler shown in Fig. 1, operated at about 550 per cent of its rated capacity on the basis of 10 sq. ft. of total boiler, economizer and heating surface to the rated horsepower; second, arranged with tubes of the proper diameter so they could be cleaned internally; third, the water in the boiler could be drained out.

Looking into the future and considering possible developments of the drumless boiler, it is evident that by departing from one or another of these features embodied in the experimental boilers it may be possible to build a boiler of cheaper construction. Nobody can say what the ultimate solution will be should drumless boilers come into use for high pressures. In all such boilers, the problems of starting up and stopping, and sudden changes of the rate at which steam is used, are much more difficult to handle than in ordinary boilers.

New Texas City Diesel Station in Operation

CLOSED COOLING WATER SYSTEM, RAIN WATER STORAGE, WATER TURBINE DRIVEN PUMPS AND UNUSUAL ARCHITECTURAL TREATMENT CHARACTERIZE THE STATION. BY T. A. BURDICK*

AT TEXAS CITY, Texas, an important sulphur and oil port, not far from Galveston, the Texas-Louisiana Power Co. recently completed a new Diesel operated central station with an installed capacity of 1960 hp. in three units.

FIG. 1. THE PLANT WITH ITS TROPICAL SETTING IS A FINE EXAMPLE OF THE GROWING APPRECIATION OF ATTRACTIVE POWER STATIONS

This new oil engine plant replaces a steam turbine plant which has been in operation for a period of more than 17 yr. The steam plant has been operated on natural gas fuel and the turbine units are condensing, ample circulating water being available due to the fact that Texas City is located on tide water. On first thought, it would appear that the steam plant is the logical type to build and operate in this particular location. There are, however, certain characteristics of the power load to be handled and of the real estate available on which the plant could be located which convinced us that an oil engine plant could be built more quickly and operated more economically than a steam plant.

Equipment in the old steam plant was depreciated to a point where economical operation was no longer possible. Furthermore, the fact that the old plant was located on space required by the Terminal Railway Co. made it necessary that a complete new plant be built. The power load in Texas City has a decided up and down characteristic, due to the fact that a large percentage of the power is used in the loading of ships. There are times when several ships are loading that the power demand is at the peak. Other times, when no ships are in port, the load becomes rather light for considerable periods of time. Standby losses between periods of maximum load are found to be much less in an oil engine plant than they are in a steam plant. Labor and fuel costs are also found to be much in favor of the oil engine plant.

PLANT COMPLETED IN FOUR MONTHS

Construction work on the new plant was commenced on February 19, 1928, and the plant went into regular service with all units on June 23, 1928. Design and construction was handled by the engineering and construction department of the Texas-Louisiana Power Co. The building is of steel frame with solid brick walls faced with a gray speckled rough texture face brick from Perla, Ark. The interior walls are finished with two coats of paint and the exterior trimmed with cut stone from Leuders, Texas. The engine room floor was elevated to a point above the highest known flood level in Texas City and the grounds are being filled and sodded to a level slightly below the engine room floor.

STATION IS WELL ARRANGED

Three engines have been installed in the plant and space has been provided for installation of a fourth unit. Two engines are rated at 700 hp. and the third at 560 hp., all features of the machines being identical with the exception that the larger ones are five-cylinder and the smaller one four-cylinder. Engines are of the full Diesel type, 16-in. bore, 20-in. stroke, two-cycle, solid injection, and operating at 257 r.p.m. Each engine is direct connected to a 2400-v., 3-phase generator and a 125-v., direct current exciter.

Features of particular interest in regard to the engines are built-in scavenging pumps, oil cooling of the pistons by forced circulation, a complete pressure

*Chief Engineer, Texas-Louisiana Power Co., Ft. Worth, Tex.

lubricating system, motor driven synchronizers and compressed air starting. Air filters and muffler chambers have been installed in the scavenging pump intakes to insure a clean supply of fresh air for the engines and to eliminate undue noise and vibration. A lubricating oil pump installed with each engine circulates in the neighborhood of 100 gal. of oil per minute against a head of 40 lb. Oil from this pump circulates through the pistons as a cooling medium. The lubricating oil pump is so located that the suction is always flooded. Oil is taken from the base of the machine and forced through a shell and tube type cooler and a twin strainer before it reaches the engine.

Wiper oil drained from the cylinders is carried off to a tank located under the floor, in which it is stored. After a sufficient quantity has accumulated, this oil is reclaimed through centrifuges and returned to the circulating system. Each engine is provided with pyrometer equipment for indicating temperatures of the exhaust from each cylinder. Two air compressors have been installed for the supplying of starting air at 250 lb. pressure. One of the compressors is motor driven and this is the one normally used. The second compressor is driven by a gasoline engine and has been installed for the purpose of furnishing starting air in case the plant happened to be shut down and the air supply exhausted, under which condition it would be impossible to operate the motor driven compressor.

Fuel oil storage consists of three 10,000-gal. horizontal cylindrical tanks located on the rear of the property and some distance away from the building. These tanks are sufficiently elevated so that gravity flow is obtained from the storage to the plant. Oil is handled directly from tank cars on an adjacent siding into the storage tanks by means of a motor driven rotary pump. A heater has been installed at the storage tanks for warming the fuel during cold weather. This heater is of the shell and tube type with warm water from the jacket system, bypassed through the tubes as a heating medium while the fuel oil is circulated through the shell.

Water for cooling of the engines is supplied from a recirculating system of the closed type. Jacket water is handled through centrifugal pumps from a sump located under the engine room floor. It is forced through a set of brass heat exchanger coils built into the base of an atmospheric cooling tower and thence to the engine jackets and back to the sump. Other pumps are used for recirculating raw water continuously over the cooling tower.

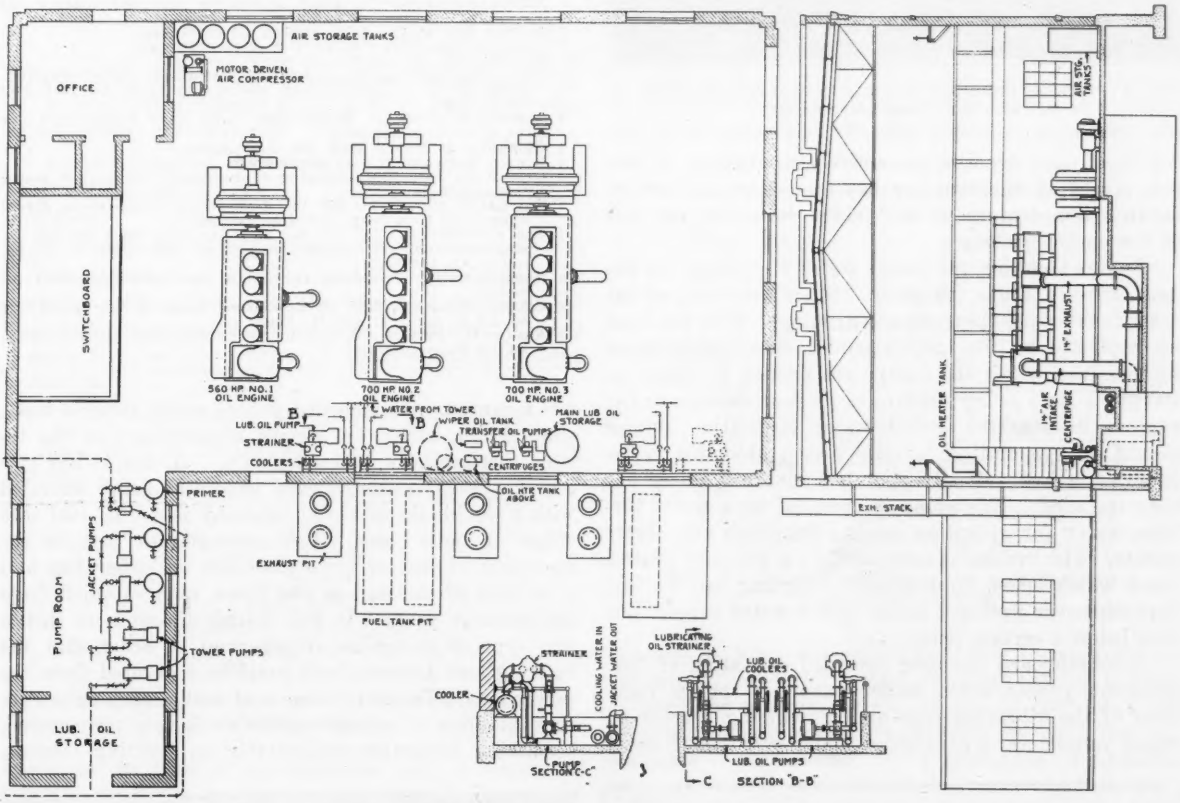


FIG. 2. PLAN AND CROSS SECTION OF THE TEXAS CITY STATION SHOWING THE DETAILS OF THE AUXILIARY ARRANGEMENT

Raw water is collected in a flume near the base of the tower and distributed from that over the heat exchanger coils. In this system jacket water is never exposed sufficiently to the atmosphere so that any appreciable evaporation can take place; consequently, once the system is filled, a very small quantity of make-up will be required. In this particular plant make-up will consist of rain water drained from the plant roof. Scaling in the engine jackets and in the piping, together with operating troubles which are caused by the build-

FIG. 3. THREE ENGINES WITH A COMBINED RATING OF 1960 HP. ARE INSTALLED

ing up of scale deposits, are entirely eliminated. A two-pen recording thermometer has been installed for recording temperature of the jacket water in and out of the engine jackets.

Pumps handling the jacket water are located on the floor directly above the sump. Since these are of the centrifugal type, they require priming. This has been accomplished by the installation of automatic primers by means of which the pumps are primed instantly on starting. As a safety feature to prevent damage to the engines in case the jacket water circulating pumps should cease operating for any reason unknown to the operator, a hydraulically operated auxiliary pump has been installed. This pump is operated by a water turbine, water for operation coming from the city water system. The turbine is controlled by a pressure control valve which opens automatically, starting up the turbine whenever pressure in the jacket water supply line falls below a certain point.

A switchboard has been provided consisting of four generator panels, seven feeder panels, a voltage regulator of the vibrating type and a swinging bracket on which voltmeters, synchroscope and power factor meter

PRINCIPAL EQUIPMENT OF TEXAS CITY PLANT OF TEXAS LOUISIANA POWER CO.

2 Fairbanks-Morse Co. 700-hp., 5-cylinder, 16-in. bore, 20-in. stroke, 2-cycle, solid injection, vertical, Diesel engines each direct connected to a 575-kv-a., 257-r.p.m., 2400-v., 3-phase, 60-cycle generator and a 15-kw., 125-v. exciter.
1 Fairbanks-Morse Co. 560-hp., vertical, solid injection, 2-cycle, Diesel engine, direct connected to 450-kv-a., 257-r.p.m., 2400-v., 3-phase, 60-cycle generator and a 12.5-kw., 125-v. exciter.
1 Westinghouse Elec. & Mfg. Co. switchboard consisting of four generating panels, 7 feeder panels, 1 regulator panel and 1 swinging bracket.
2 Fairbanks-Morse Co. jacket water pumps with capacity of 420 g.p.m. each against total head of 60 ft., driven by 10-hp., 220-v., induction motors.
1 DeLaval Steam Turbine Co. jacket water pump with a capacity of 420 g.p.m. against total head of 60 ft. direct connected to a 10-hp. water turbine.
2 Fairbanks-Morse Co. cooling tower raw water pumps with capacity of 560 g.p.m. against total head of 60 ft. each driven by a 15-hp., 220-v. induction motor.
3 Geo. B. Roper Corp. rotary lubricating oil pumps with capacity of 100 g.p.m. against total head of 60 lb., each pump direct connected to a 7.5-hp. induction motor.
3 Fairbanks-Morse Co. shell and tube type lubricating oil coolers.
3 Andale Engrg. Co. 4-in. duplex oil strainers.
2 Sharples Specialty Co. No. C-4-A centrifuges.
20 Midwest Air Filters Co. air filter sections.
1 Flour Construction Co. California Redwood, self-supporting, wide louvre, cooling tower, measuring 22 ft. by 24 ft. by 30 ft. high.
4 Griscom-Russell Co. R-240 bent tube heat exchangers for base of cooling tower.
1 Chisholm & Moore Mfg. Co. 5-t. crane.
3 Brown Instrument Co. pyrometers.
1 Bristol Co. two pen recording thermometer for jacket water temperatures.
1 Fairbanks-Morse Co. 250 lb., 2-stage air compressor direct connected to a 3-hp. gasoline engine.
1 Rix Compressor Co. 250-lb., 21 c.f.m., 4.5 by 2 by 4.5 in. single-acting air compressor, close belted to a 7.5-hp. induction motor.
1 Heat Transfer Products, Inc. shell and tube type fuel oil heater.
1 Viking Pump Co. fuel oil unloading pump with capacity of 35 g.p.m. against 100 ft. head.
3 Automatic Primer Co. automatic primers for jacket circulating water pumps.

are mounted. Switchboard panels are of natural black slate, 90 in. high. Oil circuit breakers are of the remote mechanically controlled type. A double bus system has been installed, each generator being supplied with a double-throw switch whereby it can be tied into either or both buses. This arrangement permits the operation of one or more machines on either bus and a division of the load in two parts, each supplied from independent units. It was found desirable to install this type of switching arrangement in order that the lighting and domestic load could be separated from the power load. The latter load is of such a varying nature that its effect on voltage regulation is very pronounced, something altogether undesirable on lighting circuits.

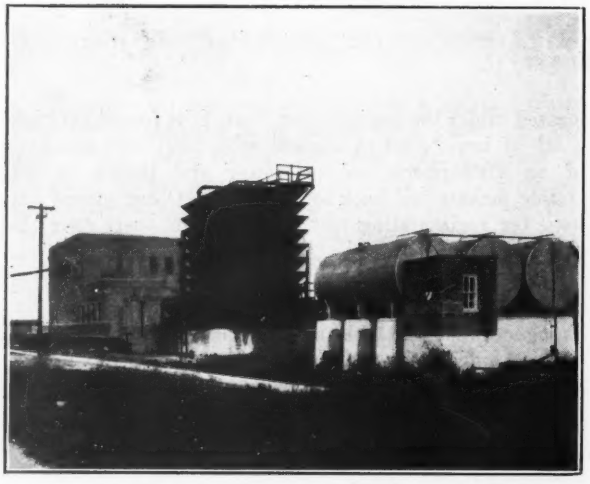


FIG. 4. JACKET WATER IN A CLOSED CIRCUIT IS COOLED IN COILS IN THE BASE OF THIS COOLING TOWER

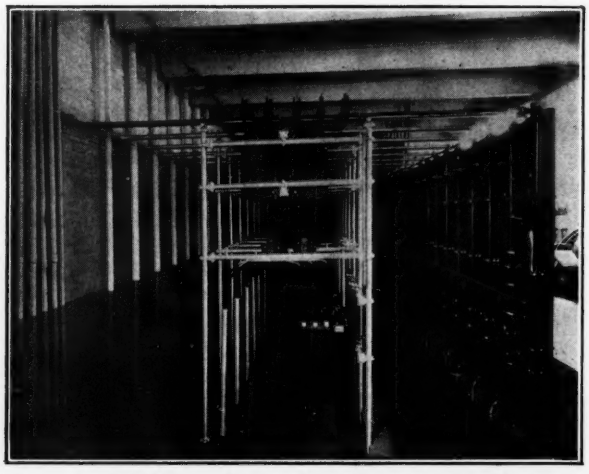
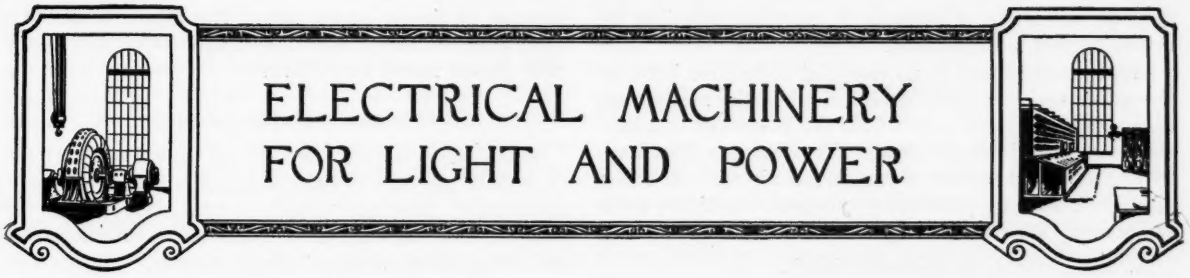


FIG. 5. REMOTE CONTROLLED SWITCHES ARE CONVENIENTLY ARRANGED FOR INSPECTION AND REPAIR



Reactive Component in A.C. Circuits

PART IX. APPARATUS FOR POWER FACTOR CORRECTION. COMPENSATED INDUCTION MOTORS, SYNCHRONOUS MOTORS, PHASE MODIFIERS. BY V. E. JOHNSON

FOR THE PURPOSE of correcting low power factor in alternating current circuits, three principal types of equipment are available. These are:

A. Compensated induction motors.

B. Synchronous motors and synchronous phase modifiers.

C. Static condensers or capacitors.

These have been given some brief consideration in previous articles from the standpoint of fundamental electrical characteristics, but their importance justifies a more detailed description of their construction and operation.

COMPENSATED INDUCTION MOTORS

As a result of the desire to produce a motor having characteristics that combine in a practical form the

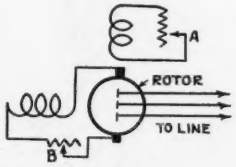


FIG. 1. SCHEME OF CONNECTIONS OF COMPENSATED INDUCTION MOTOR

operating features of the induction and synchronous types, a variety of designs of compensated or composite wound machines have appeared. These are generally based on some scheme for injecting a unidirectional flux into the fields induced in the secondary, a basic principle that has been known to engineers for years but which, until quite recently, has not been evolved into a commercially available motor.

Figure 1 shows schematically the arrangement of the windings of a common type of compensated induction motor. The rotor is the primary member (this being contrary to the usual practice) and it is equipped with two windings, one of which is connected to the slip rings and thence to the supply circuit, while the other is tapped to the segments of a commutator. The stator also has two windings arranged with a displacement of 90 electrical degrees, between them. One of them, commonly called the "field winding" is in series with the commutator brushes, while the other (the "auxiliary winding") closes upon itself through an adjustable resistance.

During the starting period, the torque is produced in a manner essentially analogous to that in an ordinary slip ring motor and the two secondary windings have

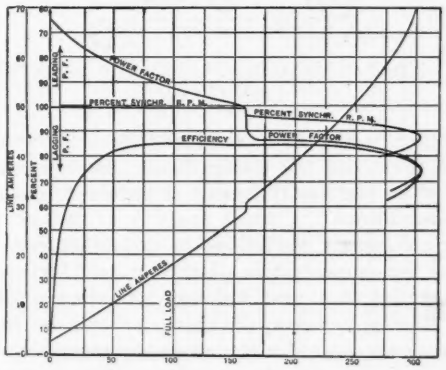


FIG. 2. CHARACTERISTICS OF COMPENSATED INDUCTION MOTOR

induced in them currents which flow through the resistance A and B. The field winding, because it closes through the commutator circuit, has an additional current component, which increases in its effect as synchronism is approached. At synchronism, the commutator sends a direct current through the "field current" —thus converting the machine into a self excited synchronous motor.

In the commercial types of this motor, the combination of characteristics obtained is desirable in that high starting torque is combined with excellent power factor at full speed. If the load is increased to the point of "pull out," the motor does not stop (as would an ordinary synchronous motor) but continues to operate as a slip ring motor, until a reduction in load permits it to pull into step again. The curves in Fig. 2 are given by the manufacturer.

Since the power factor characteristics are built into this type of motor, they are not readily adjusted. Correction is therefore obtained by a proper balance between compensated and noncompensated types, due consideration being given to ratings and operating cycles.

Synchronous motors and phase modifiers are the oldest and most common type of apparatus for power

factor improvement. The basic characteristics are such as to permit ready adjustment of the phase relations by means of field manipulation.

Electrically there is no essential difference between the motor and the phase modifier, while the mechanical differences are those only which are necessary to adapt the former to driving a load. In either one, the magnetic flux which passes through the air gap is, for a given line voltage, practically independent of the rotor excitation. Its strength depends upon three variables:

A. The current in the rotor circuit.

B. The current in the stator circuit.

C. The phase relations between the rotor flux and the stator flux.

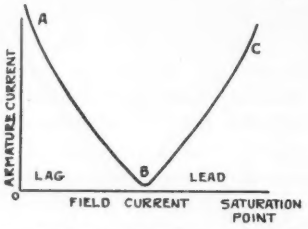


FIG. 3. TYPICAL NO LOAD "V" CURVE OF A SYNCHRONOUS MOTOR

In other words, the total magnetism is the vector sum of the rotor and the stator fluxes, the addition being made at an angular difference determined by the operating conditions. A rigid analysis of the phenomena which accompany variations in excitation and load is beyond the scope of this discussion and fortunately is not essential to a practical understanding of the subject. Briefly, however, the characteristics are such that any tendency toward a change in the magnetic strength due to an increase or decrease in excitation, is overcome by a compensatory variation in the magnitude and phase of the stator current.

Figure 3 shows what is commonly called a "V" curve. The stator current from A to C passes through a minimum point B, corresponding to a field current of n amperes. The point A represents the condition of zero amperes in the rotor; the motor is self exciting, and maintains the required constant air gap flux by taking from the line, in addition to the load current, a magnetizing current which leads the motor voltage (and therefore lags behind the generator or line voltage) and is of sufficient magnitude to provide the necessary ampere turns.

At B the field strength has been increased to a value just sufficient to maintain the proper flux density; the stator current supplies the load only, has no magnetizing function, and is in phase with the voltage.

At C the excitation has been increased to the saturation point. With this condition, the motor maintains the required constant air gap flux by taking from the line, in addition to the actual load amperes, a demagnetizing current which lags behind the motor voltage (therefore leading the line voltage) and is of sufficient magnitude to reduce the magnetism to the proper strength.

Thus, the value and phase position of the stator current taken by a synchronous motor can, by means of field manipulation, be controlled within the wide limits imposed by rating and design. This characteristic provides a convenient means for compensating for undesirable power factor conditions.

Synchronous Motor Applications

Synchronous motors have several drawbacks that prevent their use on general applications. They are more complicated than the induction type, due to the fact that separate excitation is required, necessitating an exciter or other source of direct current. This in turn adds to the number of steps in the starting operation, and increases the possibilities of mistakes. The starting torque is inherently low, varying within wide limits for different sizes and designs, but falling to a minimum value of about 25 per cent full load torque.

They are, however, well adapted to driving fans, compressors, pumps, generators and other loads of a similar nature, in which the starting operations are comparatively few. The handicap of the complicated switching incident to the starting operation can be largely overcome by the use of automatic controllers, though the use of these is hardly justified on small drives, due to the high cost of the equipment.

Use of magnetic or friction clutches permits the application of synchronous motor drives under conditions in which the starting torque is beyond the capacity of the

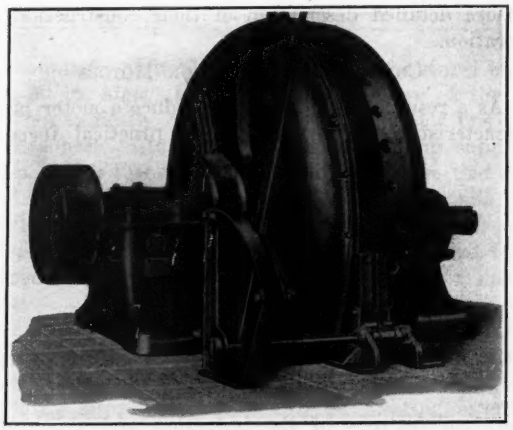


FIG. 4. ONE TYPE OF SYNCHRONOUS MOTOR FOR HEAVY STARTING DUTY

machine itself. This arrangement allows the load to be applied after the motor is locked into step.

Because of the complicated and bulky field structure resulting in high cost, the use of small, high speed motors is precluded, but on large, slow speed applications, the advantage is in general on the side of the synchronous motor and its use would very often be sound engineering, regardless of power factor conditions. Between these two extremes is a broad band of ratings where the decision must be based on a consideration of the cost, characteristics and convenience. Reliability is sometimes named as another deciding factor, but with modern engineering and construction there is little to choose between the synchronous and the induction types.

Standard synchronous motors do not differ in construction from a generator, except that damper wind-

ings of a more or less squirrel cage type are installed on the rotor to provide higher starting torque.

For heavy starting duty, one of two mechanically equivalent schemes is used. One of these, Fig. 4, consists of a motor having the stator arranged to rotate. During the starting operation, the field (being coupled to the load) remains stationary, while the stator revolves about it at an increasing speed until locked into step at synchronism. At this point, a brake is applied to the periphery of the rotating stator and as it slows

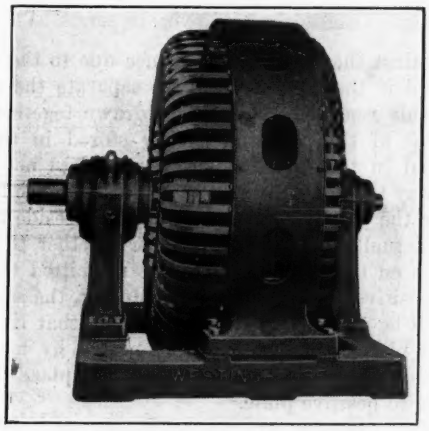


FIG. 5. CLUTCH TYPE SYNCHRONOUS MOTOR

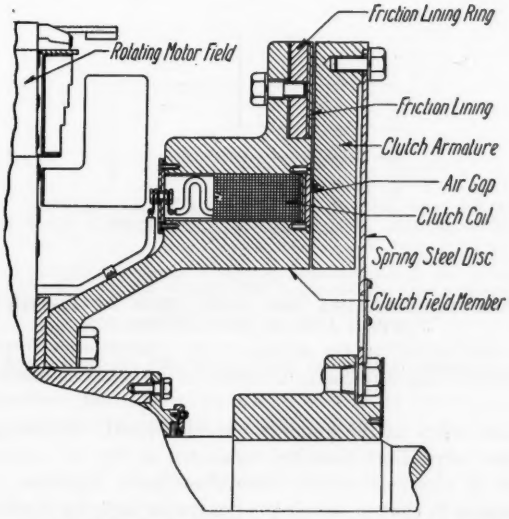


FIG. 6. CROSS SECTION OF BUILT-IN CLUTCH OF A CLUTCH TYPE SYNCHRONOUS MOTOR

down to a standstill, the rotor accelerates to synchronous speed.

The other scheme, Figs. 5 and 6, makes use of a rotor which is free to revolve upon its own shaft. During the starting operation, the shaft, with its connected load, remains stationary, while the rotor comes to full speed and locks into step. The load is started by means of a clutch between the field and its shaft. The auxiliary bearings are designed to permit continuous operation with a stationary shaft but the motors are seldom run that way.

Either of these schemes provides excellent starting characteristics, and are applicable to severe duty. The power factor is high at all times, being under the control of the operator. Their use is, however, considerably restricted by the high first cost.

Motor Ratings

Synchronous motors are usually rated to carry their mechanical loads at either unity or at 80 per cent leading and while it is possible to design them for other operating conditions, it is desirable to adhere to the manufacturer's established standards. The unity power factor motor is cheaper and more efficient; it is therefore preferable, except when the additional corrective capacity of the 80 per cent p.f. rating is actually required. A survey, along the lines already discussed, will often show that a judicious application of the cheaper type will provide sufficient corrective effect.

Efficiencies of synchronous motors vary with the horsepower rating and the speed but a few representative figures are given in the following tabulation. These are based on 2300-v., 3-phase, 60-cycle motors of the coupled type, so that the bearing losses are included.

		Efficiency in per cent					
		Motors rated at unity power factor			Motors rated at 80% power factor		
Horsepower output	R.P.M.	½ ld.	¾ ld.	Full ld.	½ ld.	¾ ld.	Full ld.
75	327	83.3	85.3	85.7	80.8	83.1	83.2
75	360	83.8	85.7	86.0	78.5	81.1	81.1
100	1200	87.8	89.4	90.1	85.1	87.2	87.7
200	720	90.1	91.4	91.8	88.3	89.7	90.1

Synchronous motors can not be operated at full kilovolt-ampere rating at power factors lower than that

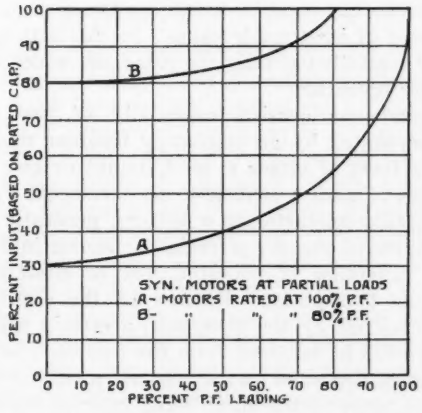


FIG. 7. CHARACTERISTICS OF SYNCHRONOUS MOTOR AT UNITY AND 80 PER CENT POWER FACTOR

for which they are designed. This is shown graphically in Fig. 7, A and B, which represents approximately the conditions applying to motors rated at unity and at 80 per cent power factor. It will be seen that in both curves, the ordinates representing the per cent possible input become successively shorter as the power factor of the motor approaches zero. At zero, the unity power factor machine can carry only about 30 per cent of its rating, while the 80 per cent rated motor can carry about 80 per cent.

This reduction in capacity is due principally to the limits imposed by the design of the field as regards heating and saturation; it is evident that a rating designed to supply the proper flux density for a given load condition, cannot provide the increased magnetic

strength demanded by greater reactive components. There is thus available as leading reactive kv-a. only a portion of the excess horsepower, so that corrective capacity must be purchased on the basis of input kilovolt-ampere rating and power factor, rather than on that of mechanical output. This will insure that the apparatus is designed with field characteristics suitable to the application.

[Editor's Note] This is the first of two articles on Corrective Apparatus in the series by Mr. Johnson. The second, discussing synchronous condensers and static condensers, will appear in a subsequent issue.

Electricity---What It Is and How It Acts*

PART XI. THEORY OF THE CONDENSER. MEANING OF CAPACITY. EFFECT OF DIELECTRIC. CHARGING CURRENT. DISPLACEMENT CURRENT

ALTHOUGH the matter was passed over briefly, the storage of energy in the distorted atoms of an insulating medium, described in the preceding article, is an extremely interesting phenomenon and one which,

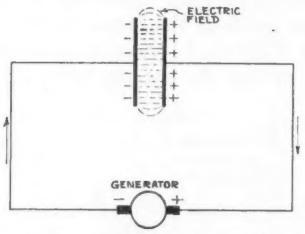


FIG. 1. CONDENSER IN CIRCUIT WITH A GENERATOR

Due to the difference of potential across the generator, electrons are removed from the positive plate of the condenser and a like number deposited on the negative plate. This causes a momentary current to flow in the direction indicated by arrows.

in the device known as the static condenser or capacitor, has proved of inestimable value. In this article, therefore, we shall discuss fully the principles which underly condenser operation.

A condenser consists essentially of two parallel plates separated by an insulating medium which may take the form of either a solid, liquid or gas. When the plates of such a condenser are connected by means of a metallic conductor to a battery, generator or any other source of electric potential, as shown in Fig. 1, a certain difference of potential will be established between the two plates. Because of the electromotive force developed by the generator, a certain number of electrons will be removed from the positive plate and a like number deposited on the negative plate, the transfer from one plate to the other being effected through the metallic circuits in which the generator is connected. During the time that this transfer of electrons is being effected, an electric current flows in the metallic circuit.

Thus, the plates become "charged" with electricity of opposite polarities—the plate carrying the excess of electrons acquiring a negative charge while the one from which they are removed, a positive charge. Furthermore, an electric field will be established between the plates, which acts in opposition to the electromotive force of the generator.

WHY THE ACTION OF THE FIELD IS OPPOSITE TO THE ACTION OF GENERATOR

A few words of explanation may make this fact more clear. In Part VI[1], it was shown that when opposite charges of electricity are separated, work is done against the attractive influence due to the electric field, and if the force tending to separate the charges is suddenly removed, they will be drawn together again by virtue of the potential energy stored in the field. As stated in that article, however, it does not matter which way the neutralization of the charges is effected—whether the plates on which the charges reside are permitted actually to come together or whether the excess electrons on the negative plate are permitted to return to the positive plate through a conductor, the same purpose will be served. It is obvious, then, that if the two charged plates were suddenly connected by a metallic conductor, a flow of electrons would take place from the negative to positive plate.

If the diagram of the condenser and generator circuit shown in Fig 1 is now examined it will be found that such a metallic circuit between the two

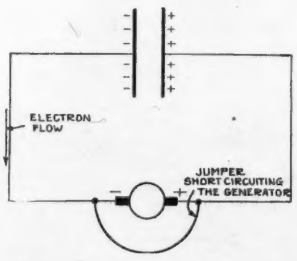


FIG. 2. DISCHARGING THE CONDENSER BY PLACING A JUMPER ACROSS THE GENERATOR

By short circuiting the generator, the electromotive force of the generator is removed from across the condenser, and the latter discharges producing a current in the direction indicated.

plates exists in the generator circuit itself. If the generator were short circuited as shown in Fig. 2, a sudden flow of electrons would take place in a direction just opposite to that in which the generator sent the electrons in charging the plates. Thus, it is obvious that the action of the field between the plates is in direct opposition to the action of the generator.

CAPACITY OF A CONDENSER

This fact being understood, it may be seen that when the electric field between the plates becomes equal in value to the difference of potential across the generator, the transfer of electrons from the positive to negative plates ceases and the condenser will be charged. From Coulomb's law,[2] it can be shown that for a given condenser, the value of the field between the plates is directly proportional to the value of the charges on

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[1] August 1 issue, page 825.

[2] Part VI, August 1 issue, page 827.

the plates; therefore, also, that the charge of a condenser is directly proportional to the difference of potential between the plates, this being the measure of the field. The ratio e/v of the charge of a condenser, e to the potential difference v, between its plates has, therefore, a constant value C for a given condenser. This value C is called the capacitance or electrostatic capacity of the condenser. In the practical system of units, the unit of capacitance is the farad, which is the capacitance of a condenser which requires a difference of one volt between its plates to store a charge of one columb. In terms of electrons, a columb equals 6.3×10^{18} units.

Charging Current

The current of electricity along the metallic circuit which has been shown to take place while the condenser was being charged is called the charging current of the condenser. If the condenser plates were contained in a perfect vacuum, this charging current would be the only displacement of electricity taking place in the system during the time of charging, but condenser plates are rarely in vacuum and usually have some insulating material between the plates, which causes an additional displacement of electricity, as will now be described.

In our study of the action of insulating material in an electric field in the preceding article, we learned that the atoms of insulating materials are distorted

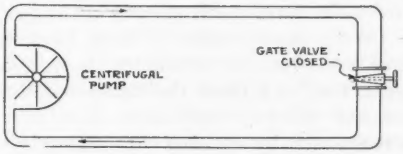


FIG. 3. HYDRAULIC ANALOGY TO SHOW THE SIGNIFICANCE OF CHARGING CURRENT IN A CONDENSER IN VACUUM

When centrifugal pump is started pressure builds up in upper leg until the back pressure just balances the pump pressure. The momentary current which results is due to the compressibility of the water.

when an electric field is applied. The energy necessary to produce this distortion was shown to be derived from the potential energy of the field itself.

Displacement Current

Assuming now that the condenser in Fig. 1 has no dielectric material of any kind between its plates and that it has been charged to a certain potential by the generator, let an insulating medium be inserted between the plates. Under the action of the field, the atoms of this insulating medium will undergo distortion with a consequent absorption of potential energy from the field. This results in a lowering of the potential on the plates, so that in order to maintain it at its previous value, additional electrons will have to be supplied to the negative plate, giving rise to an additional current. This current is known as the displacement current.

From this, it follows that the capacity of a condenser is dependent to a certain extent upon the medium between the plates, that is, upon the dielectric constant k, of the medium. If a charge e is required to produce a field f in vacuum, a charge k e will be required to produce the same field in an insulating medium of dielectric constant, k. If then $C = e \div v$ is the capacitance of a condenser in vacuum, the capacitance of the same condenser in an insulating medium of dielectric constant k, will be

$$C^1 = \frac{k\ e}{v} = k\ C$$

where C^1 is the capacity of the new condenser.

Thus, we have here a simple method of determining the dielectric constant of any insulating material by first measuring the capacitance of the condenser in vacuum and then of the same condenser using as a

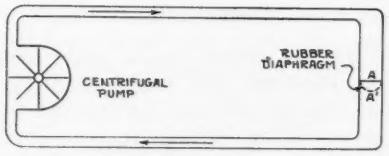


FIG. 4. HYDRAULIC SYSTEM EQUIVALENT TO AN ELECTRIC CIRCUIT HAVING A CONDENSER WITH MATERIAL DIELECTRIC

In this case, the closed valve of Fig. 3 is replaced by a flexible diaphragm. Under the pressure of the pump the diaphragm is distended, resutling in a much larger charging current than was the case in Fig. 3.

dielectric the material under test. The ratio of the latter to the former gives the dielectric constant k.

Hydraulic Analogy

In forming a conception of the action taking place in charging a condenser, the two causes of the charging current must be definitely understood. The charging current of a condenser in vacuum is due to the compressibility of the electrons in the metallic conductor of which the circuit is composed. When a dielectric other than vacuum is used, however, in addition to the current due to the compressibility of the electrons in the metallic conductor, there is also a current due to the distortion of the atoms in the dielectric.

A simple hydraulic analogy may make this very clear. In Fig. 3 there is shown a centrifugal pump connected into a rectangular system of pipes having a gate valve in the leg opposite the pump. The pump corresponds to a direct current generator. If the gate valve is closed, assuming the entire system to be filled with water, and the pump started, a pressure will be built up in the upper half of the system. For a brief instant, a current will be established but as soon as the back pressure equals the pressure of the pump, this current will cease, even though the pump is maintained in operation. This momentary current is due to the slight compressibility of the water and corresponds to the charging current of an electric condenser in vacuum.

Suppose, now, that the valve is replaced by a flexible diaphragm of rubber, as in Fig. 4. Under these conditions, when the pump is started, the pressure will distort the diaphragm from a position A to a position A^1 and a considerably greater current will flow. When the diaphragm has reached a position A^1, the elastic force of the material will just balance the pressure due to the pump and the current will cease. Thus, in a

circuit of this kind, we have in addition to the current due to the compressibility of the water, a current due to the distortion of the diaphragm. This corresponds to the distortion of the atoms in the dielectric of an electric condenser.

In the hydraulic circuit, the charging current would be a function of the elasticity of the diaphragm, just as in the electrical circuit, it is a function of the dielectric constant. Capacity in an electrical circuit, therefore, is analogous to elasticity in an hydraulic or mechanical system.

Liability for Injury to Trespasser

LESLIE CHILDS

IT GOES without saying, that a power company engaged in handling and distributing high-voltage electricity is charged with the exercise of the highest degree of care. Particularly is this true where by any chance children of tender years may suffer injury by coming in contact with unprotected wires.

This is not all, however, for the courts have gone much farther and declared that this duty to guard high-power wires may even extend to an adult trespasser upon the company's property; and, if an injury to such a person can be shown to have resulted from the company's negligence, it may be called upon to respond in damages.

Of course, there are cases and cases of this character and, since each has been decided upon its particular facts, hard and fast rules are of little value in covering the subject. As an example, however, of how far the judicial holdings have gone in situations of this kind, the Washington case of Clark v. Longview Public Service Co., 255 Pac. 380, is well worth a brief examination.

GIRL 18 YR. OF AGE SUFFERS INJURY

In this case, the service company maintained an electrical transformer to reduce the high voltage used by it in supplying power to operate a drainage district's pumps. The transformer and pump house abutted upon a public road and a canal, the latter being the property of the drainage district. The transformer and its wires were guarded by a woven-wire fence inclosure but this fence was not very taut in places and on the north and south sides of the inclosure were holes through which a person might gain entrance thereto. A warning sign of danger appeared on the west side of the inclosure. All right.

Now, it appears, that the canal by the pump house was frequented by people fishing and the plaintiff, a girl about 18 yr. of age, accompanied her parents there for that purpose. After watching her parents fish for awhile, the plaintiff was attracted by the pumps and entered the inclosure, through one of the holes in the fence heretofore mentioned, in order to look into the windows of the pump house and see the pumps working.

In attempting to look into the pump house, plaintiff, it appears, took hold of a truss-rod and, in leaning forward, her hair blew against one of the high-voltage wires. This caused a short circuit, which resulted in current from a 6700-v. line passing into her skull from which plaintiff was seriously injured. To recover therefor, the plaintiff thereafter brought the instant action against the service company.

In defense, the service company denied that it had been negligent in guarding the transformer and set up contributory negligence on the part of the plaintiff. Further, the service company pointed out that the plaintiff was not a child and was at best a mere trespasser upon its property. The trial, however, resulted in a judgment for $27,278 in favor of the plaintiff. From this the service company appealed and the higher court in reviewing the record on the question of whether or not the service company was negligent in not making its inclosure more secure, said:

THE LANGUAGE OF THE COURT

"There was sufficient evidence to show that the appellant [service company] must have known that young and old people were in the habit of congregating in great numbers near this pump house and the jury was justified in believing that the appellant should have reasonably anticipated that young people especially might enter this inclosure through these holes and that the appellant was guilty of negligence in failing to make the inclosure more secure or in not placing a sufficient number of warnings to apprise the public of the danger lurking in the situation; * * *

"As we view it, there was sufficient proof of negligence, * * * to justify the submission of that question to the jury; * * * The duty which the owner of high-voltage electricity owes to all persons—whether invitees, licensees, or trespassers—who it may have reason to believe may come into its proximity, is to guard them from danger resulting from the dangerous appliances; and it cannot relieve itself from liability, even as against a trespasser, by showing that it merely refrained from inflicting wanton and willful injury. * * *"

Following the foregoing statement, the court turned to the question of whether the plaintiff had been guilty of such contributory negligence as to bar recovery. In passing upon this, the court, among other things, said:

"While it is true that this respondent [plaintiff] was not a mere child, still it was a question of fact for the jury to determine whether she conducted herself as a reasonably prudent person would have under the circumstances. There is some testimony that she did not know what the effect of coming in contact with these wires was. The wires themselves gave no indication of their dangerous character. The jury may have believed that she was not guilty of negligence in entering the inclosure * * * and she could not anticipate that a few loose hairs on her head would come in contact with the wire and thus create a short circuit; and altogether the proper body to pass upon the question of the reasonableness of her conduct was the jury and not the court. * * *"

Then, on the question of whether or not the judgment, namely $27,278, was excessive, the court said:

"While the verdict is large, it does not indicate that it was the result of anything except an effort on the part of the jury to measure in money the suffering and injury which this respondent has and will endure. That she escaped with her life borders on the miraculous, and that the life which she has remaining is one accompanied by constant torture is apparent. * * *

And, not being able to say that the amount which the jury awarded her is too great, the judgment is therefore affirmed."

SUMMARY

As noted in the beginning, since each case of this kind must necessarily be decided upon the facts involved, hard and fast rules on this subject are of little value. Nevertheless, the case examined constitutes a valuable illustration of how far the courts may go, in holding a power company liable in a situation of this kind.

While a power company is not an insurer of the safety of everyone that may come in contact with its high-voltage wires, the degree of care required of it is high. Truly, in the face of this rule, constant vigilance is the price of even a measure of insurance against the possibility of costly damage suits in the operation of power lines.

Higher Boiler Ratings Necessitate Care in Feedwater Treatment

INCREASINGLY HIGH boiler ratings with exceedingly severe conditions on water-screen and water-wall tubes are requiring better boiler feedwater treatment or conditioning than formerly, according to a recent report of the N. E. L. A. Increased use of evaporators indicates that distilled water for makeup is becoming an important method for feedwater treatment and that, although some operating difficulties are being encountered with certain raw waters, the general high quality of the distillate and the low net cost of the station warrant the consideration of evaporators for all installations.

In general, evaporator outputs are being kept at a high degree of purity over extended periods of service and with various grades of water. Cases of priming, reduced capacity and extended outages for cleaning have been reported, however. With some grades of raw water, chemical treatment ahead of the evaporators has been found to be an economy in the light of higher capacities and reduced outages for cleaning.

In these cases, the water treatment and the problems involved are similar to those for treatment of water delivered to the boiler direct. These operating difficulties indicate that some improvement in design is desired, especially with regard to ease and quickness of cleaning.

Heat is derived from live, exhaust and bled steam and the evaporator plant is usually introduced as a step in the station heat balance. As high as four effects in a single installation are being used.

CONTROL OF BOILER CORROSION

Control of boiler corrosion is receiving increased attention. Some companies find it necessary to vary the alkalinity, the boiler water in different plants running from slight alkaline to caustic alkalinities, ranging from 15 to as high as 350 p.p.m.

Others find that, under their particular conditions, mere alkalinity—that is, sodium carbonate alkalinity—does not suffice to inhibit corrosion regardless of the degree of such concentration and they find it necessary to treat for other salts, such as magnesium chloride, which is corrosive and which in turn will require counter treatments to guard against the danger of caustic embrittlement.

In this connection, sulphate and carbonate ratios of 3 to 1, 2.5 to 1, and 2 to 1 have been reported, with total concentration as high as 1000 to 1500 p.p.m.

DRIVING OFF OXYGEN

Although a number of companies have carried the chemical treatment of water to an elaborate degree, they are still faced with the necessity of reducing the free oxygen to a minimum, as a basic treatment in itself. The latest reports state that open type surge tanks are considered as sources of free oxygen absorption in the feed system and plans are under way to steam blanket them. Dissolved free oxygen is the only problem in a number of plants and a few are successful in keeping this low by maintaining the feedwater temperature in the open heaters constant at 210 deg. F. or higher.

Where temperature varies, the heaters were vented to the main condenser. This practice is extensively employed where the percentage of makeup is not too high in place of investing in deaerating equipment.

The companies reporting deaerating apparatus in use claim satisfactory operation regardless of type of manufacture. Those claiming satisfactory service by venting their heating equipment to the main condensers maintain that when the percentage of makeup is not too great, this method is far more economical.

REHEAT STATIONS have a considerably better Rankine cycle efficiency, analysis of several stations showing an average improvement of 13.7 per cent over the non-reheating. Part of this improvement is due to higher throttle pressures in the reheat plants, but most of it is due to the initial expansion in the superheat field afforded by the reheating.

As would be expected, local conditions of fuel and boiler room equipment influence boiler efficiency so much that the comparison on a straight thermal basis is of little value. In general, plants with high boiler efficiencies have either air preheaters or economizers or both and burn good fuel.

ACCORDING TO a statement by John L. O'Toole, vice-president of the Public Service Gas & Electric Co., the Patterson, Camden and Trenton electric generating stations are being dismantled. The passing of these three units will leave Public Service with six generating stations—Kearney, Essex, Marion, Perth Amboy and Burlington in active operation and Cranford as a standby.

When the Public Service Corporation of New Jersey was organized in 1903, 28 generating stations were in operation, and these together had a capacity of 40,075 kv-a. Nothing more strikingly illustrates the phenomenal advance of the electrical art within the past few years than the fact that the five remaining units have, at the present time, a capacity of 607,526 kv-a. In addition, Cranford has 4350 kv-a. Thus, the total generator capacity as of September 1, 1928, was 611,876 kv-a.

New Unit Adds 30,000 Kw. to Saginaw River

STOKERS USING PREHEATED AIR, EXTRACTION HEATING AND THREE SOURCES OF HOUSE ELECTRICAL SERVICE, FEATURES OF CONSUMERS POWER CO.'S EXTENSION. BY J. W. L. HARRIS*

SAGINAW RIVER steam plant of Consumers Power Co. near Saginaw, Michigan was built in 1923-24 and consisted originally of two units of 20,000 kw. capacity each and four 9280-sq. ft. cross-drum boilers† having side and rear water walls. To this installation one 12,337-sq. ft. boiler unit was added in 1926. Because of the rapidly growing load in the eastern part of the state and in the Saginaw district and the need of additional steam capacity on the 60-cycle system, it was decided in 1926 to install a third unit of 30,000 kw. capacity, together with a 3500-kw. house generator. Construction of this addition was started in the spring of 1927, the schedule calling for putting the generator on the line by June 1, 1928. The new unit was put on the line for the first time on April 29 or approximately one month in advance of schedule. The addition of this 30,000-kw. unit gives the Saginaw River plant a total capacity of 70,000 kw., with provisions for future extensions up to 150,000 kw. With the completion of the present installation, the total steam capacity of the Consumers Power Co. will be 186,000 kw., out of a total steam and hydro capacity of 312,765 kw.

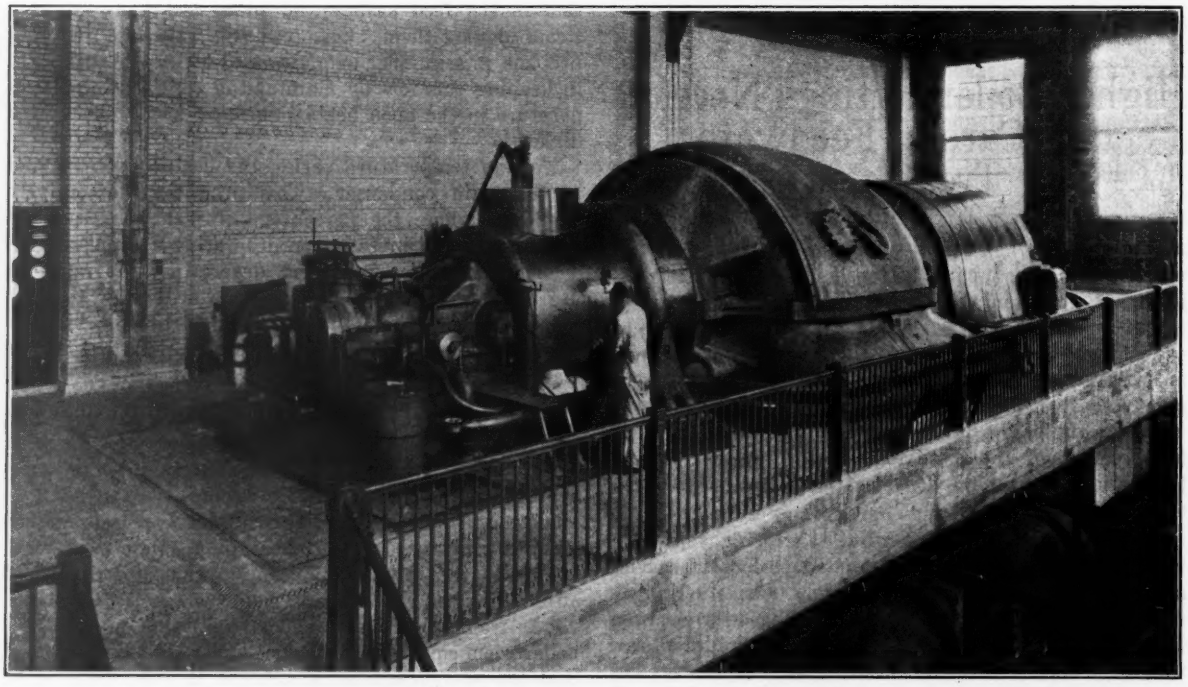


FIG. 1. NEW UNIT AT SAGINAW RIVER STEAM PLANT DESIGNED FOR 30,000 KW.

Building extension for the 30,000-kw. unit and house generator is 148 ft. long by 97 ft. wide. The boilers are arranged in a single row, the boiler room being 49 ft. by 10 ft. wide and running the full length of the turbine room, from which it is separated by a brick dividing wall. The building is of wire-cut red brick, laid up in colored mortar with raked joints and concrete trim poured in place. Interior walls are sand lime brick painted a buff yellow, except for the lower 6 ft. which is brown. The turbine room floor is light terrazzo with dark border. On account of the larger size of the new unit, it was found necessary to put the base slab under the turbine room extension about three feet lower than that under the old turbine room. This, however, did not entail any structural difficulties. A 60-t. motor-driven crane of 45-ft. span with a 15-t. auxiliary hook runs the full length of the turbine room and may be used for any one of the four units.

Underfeed stokers are used in the original plant and it was decided to continue with this method of firing. For the four new boilers, stokers have 12 retorts, 45 tuyeres with double 18-in. roll crushers and a projected grate area of 385.3 sq. ft. Furnace volume, from top of grates to center of first row of tubes is 6000 cu. ft. Stokers are driven by motors with 300, 600 and 1200 r.p.m. windings, connected to a controller which varies the speed in a large number of stages between 300 and 1200 r.p.m.

Coal is brought to the plant by railway and dumped into track hoppers which are designed for a future car dumper. Two feeder belts dump the coal on an in-

*Engineering Department, Consumers Power Co.

†Later two rows of tubes were added to these boilers, increasing the heating surface to 10,780 sq. ft. within the boiler proper.

clined belt conveyor which carries it over a magnetic pulley to the crusher house. Coal passes either through or around the crusher to another inclined conveyor belt on 245-ft. centers which carries it to a traveling, tripper belt conveyor, 304 ft. on centers, running the full length of the bunkers for nine boilers. At the crusher, coal can also be discharged to an inclined belt conveyor which delivers it to the drag-line supplying the 75,000-t. outside storage pile, where it is distributed by a drag scraper system with gasoline-propelled tail-car. The drag-line is equipped with a 10-t. bucket and can handle 375 t. of coal per hour either to or from storage. The head post is directly over the reclaiming hopper, which has a 36-in. belt conveyor feeding to the conveyor leading from the track hoppers. The capacity of the crusher is 200 t. per hr. and provision has been made for a future unit of the same size.

All belt conveyors have capacities of 350 t. per hr. and the traveling tripper can handle 200 t. per hr. The conveyor from the crusher to the boiler room enters at a point which will ultimately be the center of the building. Provision has here been made for a future 200 t. tripper. Bunker capacities are 140 t. each, or sufficient for approximately 24 hr. supply per boiler. Motors on the coal handling equipment are interlocked so that all must be operated in proper sequence. Any motor which cuts out will automatically stop all equipment feeding up to its portion of the operating sequence.

Under each boiler a hopper with motor-operated gates dumps ash into a gravity sluice. Ash is sluiced to a central sump from which it is pumped to low ground around the plant by two 10-in. dredge pumps either of which can handle the full capacity of the sluice.

Boilers Designed for 460 lb.

To the boiler plant were added four 12,340-sq. ft. cross-drum units, 36 tubes wide and an average of 14 tubes high in the main bank, with water-cooled side and rear walls. These boilers are designed for a maximum working pressure of 460 lb. gage. Combination radiant and convection type superheaters good for a working pressure of 400 lb. gage are designed to raise the temperature of 120,000 lb. per hr. of 0.99 quality steam, at 375 lb. gage, to 725 deg. F. total temperature.

Air preheaters of the regenerative type are used, with integral axial-flow forced and induced draft fans driven by variable-speed, slip-ring motors. The forced draft fans have a capacity of 220,000 lb. of air per hr. under a static pressure of 8.3 in. of water at the entrance to the air ducts with a maximum air temperature of 120 deg. F. to the forced draft fan. Induced draft fans have a capacity of 275,000 lb. of gas per hour at a temperature of 600 deg. F. from the economizer and a static draft of 6.6 in. of water at the gas inlet to the preheater. Gases from the economizer pass through the air preheater before passing to the induced draft fans. The gas temperature to the induced draft fans will not normally exceed 300 deg. F.

Serving the nine boilers under the new arrangement are two 400-g.p.m., one 500-g.p.m., one 600-g.p.m. and two 1000-g.p.m. boiler feed pumps. All except the 500-g.p.m. pump are motor-driven. The 500-g.p.m. pump is turbine-driven and is used for standby service only.

The 30,000-kw. generator is driven by a reaction turbine which is normally bled at three points. When operating straight condensing at 29 in. vacuum and rated generator load (30,000 kw. at 80 per cent power factor) this machine has an estimated steam consumption of 9.47 lb. per kw-hr. and is capable of carrying 37,500 kw. (at unity power factor) at a rate of 9.6 lb. per kw-hr. The turbine is designed to be safe for maximum steam conditions of 400 lb. gage and 750 deg. F., but will be operated normally with an average throttle pressure of 350 lb. gage and temperature of 700 deg. F.

Steam pressures at bleed points when operating straight condensing at full load and 29 in. vacuum are 157, 55, 20.4 and 5.8 lb. absolute. The first bleed point is used only for the evaporator cracking line and is only used occasionally. From the second point, steam is bled to two evaporators, operated in parallel, single effect, each capable of vaporizing 9000 lb. of water per hour, equivalent to about 5½ per cent makeup at full load. Vapor is condensed in the third point bleed heater.

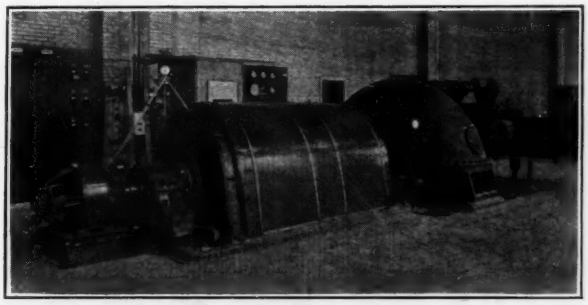


FIG. 2. HOUSE GENERATOR NO. 1 RECENTLY INSTALLED IN SAGINAW PLANT

Two-pass, low-pressure closed feedwater heater takes steam from the third bleed point at 19.6 lb. absolute and from the vapor lines from the evaporators. This heater has sufficient capacity to heat 330,000 lb. per hr. of condensate from 156 deg. F. to 220 deg. F. The fourth bleed point supplies steam at 5.08 lb. absolute at full load to a two-pass closed feedwater heater with capacity to heat 330,000 lb. of condensate per hour from 81 deg. to 156 deg. F. Both of these closed heaters are designed for a terminal difference of 7 deg. F.

Turbine exhausts into a 30,000-sq. ft. single-pass radial flow surface condenser with capacity to condense 330,000 lb. of steam per hour at 28 in. vacuum (referred to a standard 30-in. barometer) using 56,000 g.p.m. of 80-deg. cooling water. The condenser is equipped with a two-stage twin air-ejector with surface type intercooler and after condenser having three condensate passes and one raw water pass. The condenser is attached directly to the turbine and is supported on springs so adjusted that there is a slight downward pull on the exhaust nozzle when the condenser is empty and a maximum pull of 150,000 lb. under operating conditions.

The 3500-kw. house generator is driven by a 14-stage impulse turbine. Steam consumption of this unit is 10.06 lb. per kw-hr. at 29 in. vacuum (referred to 30-in. barometer) when carrying rated load of 3500 kw. at 65 per cent power factor. Steam is bled from one stage only at 34 lb. absolute at full load and supplies a four-pass, low-pressure closed feedwater heater with a ca-

pacity to heat 45,000 lb. per hour of condensate from 81 deg. to 221 deg. F. with a 7 deg. F. terminal difference. Bled steam can be throttled at the higher loads if the condensate from this heater becomes too hot.

This unit exhausts into a 4000-sq. ft. single-pass, down-flow type surface condenser, with two-stage twin air ejector and surface type inter-cooler and after-condenser having three condensate passes and one raw water pass.

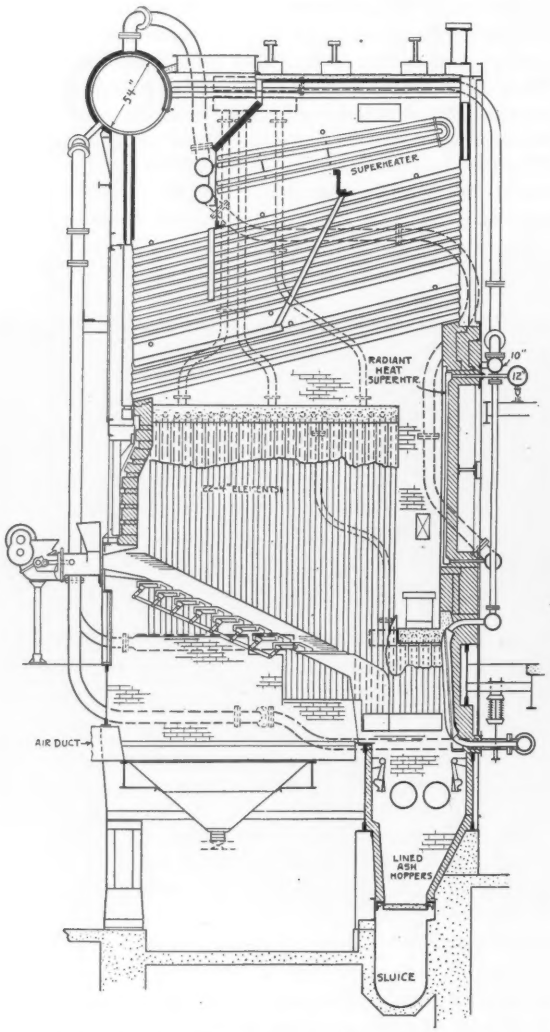


FIG. 3. USE OF PREHEATED AIR, WATER WALLS, RADIANT AND CONVECTION TYPE SUPERHEATERS ARE FEATURES OF NEW BOILERS

River Water Used for Condensing

Condensing water for the large unit is supplied from the river through a concrete intake duct 680 ft. long, which is carried across the discharge channel from the two 20,000-kw. units. The concrete discharge duct 315 ft. long parallels the intake duct and empties into the same discharge channel as the two old units. Circulating water for the house generator is supplied through a separate 27-in. diameter concrete duct. Since the necessary extension to the outdoor switching structure passes over the circulating water ducts, the new intake and discharge ducts were both made of sufficient capacity to take care of another unit.

Although it adjoins the old building, the new screen-house is entirely separate so far as its operation is concerned. For the 30,000-kw. unit, there are two vertical traveling screens, each capable of passing 29,000 g.p.m. with water at a level of 10 ft. in the intake chamber. For the house turbine, there is a separate traveling screen passing 8500 g.p.m. Two 30-in., 250-hp. motor-driven pumps under a total head of 24 ft. supply the large unit with circulating water. The house turbine is supplied by one 20-in., 75-hp. motor-driven pump, under a total head of 24 ft. The new screen-house and intake chamber are of sufficient size to take care of two additional pumps and equipment duplicating that for the present 30,000-kw. installation.

Three Sources of Station Power

Station power supply is quite different from any other on the Consumers Power Co. system; it is, perhaps, a little unusual in that there are three independent sources of supply. One source is the 3500-kw. 2500-v. house generator, which is stepped down to the 480-v. station bus through a bank of three 2000-kv-a. transformers. The other two sources are two banks of three 1000-kv-a. transformers, both of which step down from the 22,000-v. substation to the 480-v. bus. These three sources feed three separate 480-v. station power buses, which can be tied together by means of bus tie oil circuit breakers. Each circuit can be fed through gang-operated disconnect switches and oil circuit breakers from either the house generator bus or one of the transformer buses. The gang-operated disconnect switches are so arranged that a transfer from one bus to the other can be made under load provided the bus tie breakers are closed. It is expected to operate this unit disconnected from the system carrying the essential auxiliaries.

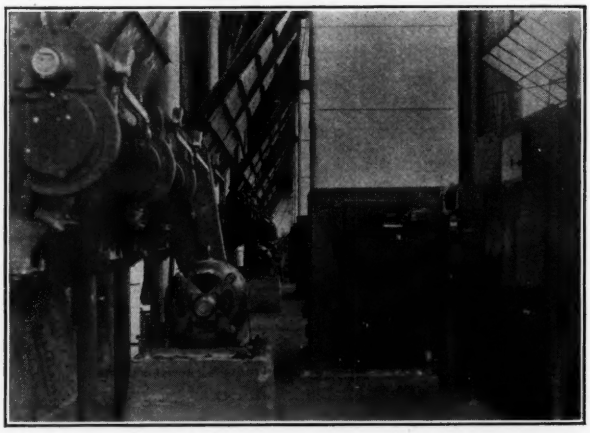


FIG. 4. FIRING AISLE AT SAGINAW PLANT

The new generator is rated at 37,500 kv-a., 30,000 kw. 80 per cent power factor, 1802 amp., 12,000 v., 60 cycles, 3 phase, 1800 r.p.m. Excitation is by a 250-v. direct-connected exciter with a 125-v. pilot exciter. The house generator is rated at 5385 kv-a., 3500 kw., 65 per cent power factor, 2500 v., 1245 amp., 3 phase, 60 cycle, 3600 r.p.m., and is equipped with a direct-

connected exciter. Since all motors in the plant, except the variable speed fan motors, are direct across-the-line starting, the house generator is equipped with a quick response voltage regulator.

For the 30,000-kw. unit, a two-pass generator air-cooler with 14,550 sq. ft. of cooling surface circulates and cools 100,000 cu. ft. of air per minute to 104 deg. F. final temperature. The house generator has a 10-pass air cooler with 2950 sq. ft. of surface, cooling 17,500 cu. ft. of air per minute to 104 deg. F. final temperature. Water for both air-coolers is taken directly from the circulating water supply and they are designed to operate with a maximum circulating water temperature of 85 deg. F.

Station power switchboard is on the main turbine room floor and the main power switchboard for control of generators is in a switchboard gallery overlooking the turbine room and the outdoor substation. All motors are 440-v., 3-phase, 60-cycle units and nearly all are started from a station near the motor.

FIG. 5. COAL STORAGE SYSTEM AS SEEN FROM TOP OF POWER PLANT BUILDING

Each of the three main generators feeds through an auto-transformer to the 22,000-v. duplicate bus which in turn is connected through two 45,000-kv-a. banks of three 22/140-kv. transformers, the second bank of which is part of the present installation, to the 140-kv. duplicate bus. Power is transmitted at 22,000 and 140,000 v. and the 22,000-v. bus may be energized either direct from the generators or from incoming 140,000-v. lines.

Construction was carried out by the construction department of Consumers Power Co. The plant was designed by and constructed under the supervision of the Commonwealth Power Corp. of Michigan, Wm. W. Tefft, chief engineer.

WORK HAS BEGUN by the Great Western Power Co., San Francisco, Calif., on its new proposed steam operated electric generating plant on waterfront property opposite India Basin, Bay district. This work includes power plant foundations and superstructures as well as intake tunnels and miscellaneous construction. The station will be equipped for an initial output of 55,000 kw. and it is understood it will be increased at a later date.

Business-like Organization of Government Activities

FOR YEARS Congress has had under consideration improvement of the organization of the executive establishment. Important steps were taken with the establishment of government employment based upon merit and the establishment of adequate control of appropriations through the budget system but all proposals for correcting the bad functional organization under which 200 different bureaus, boards and commissions have been scattered without reference to their activities among 10 different executive departments, with 40 more independent agencies operating under the nominal direction of the President or Congress, have been futile.

Reorganization has been brought about in the Department of Commerce by Secretary Hoover who feels that it can be extended to other executive departments. He has stated that, "Our presidents have repeatedly recommended to Congress that if we could secure the grouping of the agencies devoted to one major purpose under single responsibility and authority, not only would it greatly reduce expenses of business in its contacts with government but a great reduction could be made in governmental expenditure and more consistent and continued national policies could be developed."

This reorganization plan contemplates three primary reforms: First, the grouping together of all agencies having the same predominant major purpose under the same administrative supervision; second, the separation of the semi-judicial and the semi-legislative and advisory functions from the administrative functions, placing the former under joint minds, the latter under single responsibility; and third, relieving the President of a vast amount of direct administrative labor. To accomplish such reorganization, Mr. Hoover proposes that Congress should delegate the task and the authority to bring it about to the President, a special board or, if it so desires, to a committee of its members.

In 1925, he said: "Congress courageously removed the Civil Service from politics, created the budget and established the classification. The remaining great step is to authorize somebody to reorganize the administrative arm of the government. Nor is Congress to be blamed for this situation, as it is impossible for such an overworked body to study directly and act upon the overwhelming detail involved. Nor is it possible for a great body like this to determine the right and wrong of a thousand clamors. It is not to be expected that the federal government will ever be a model of organization, but there should be aspiration to see it improved."

THE U. S. CIVIL SERVICE COMMISSION announces open competitive examination for local and assistant inspector of boilers and local and assistant inspector of hulls. These applications must be filed with the Civil Service Commission at Washington, D. C., not later than November 6. The examinations are to fill vacancies in the Steamboat Inspection Service. The entrance salaries are $3200 a year for inspectors and $2900 for assistant inspectors. For full information, address the U. S. Civil Service Commission, Washington, D. C., or the U. S. Civil Service Board of Examiners in any city.

Flow Measuring Devices for Hydroelectric Plants

LARGE UTILITY ORGANIZATION EMPLOYS VARIOUS DEVICES ALL OF WHICH UTILIZE PRESSURE DIFFERENTIALS DEVELOPED BY EXISTING FEATURES OF STATION DESIGN*

DURING RECENT YEARS, the New England Power Co. has equipped nearly all hydroelectric units with devices for indicating, relatively or quantitatively, the use of water and, in several cases, has installed the instruments to furnish charts and totalized records.

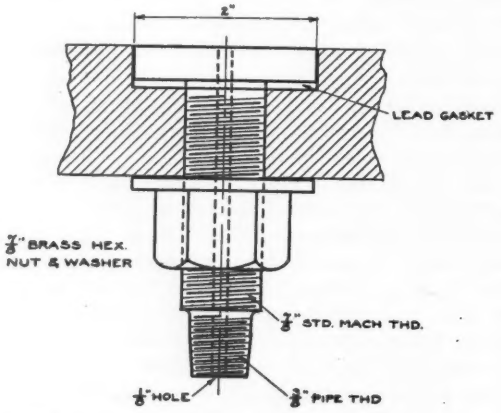


FIG. 1. BRASS PIEZOMETER ORIFICE STUD

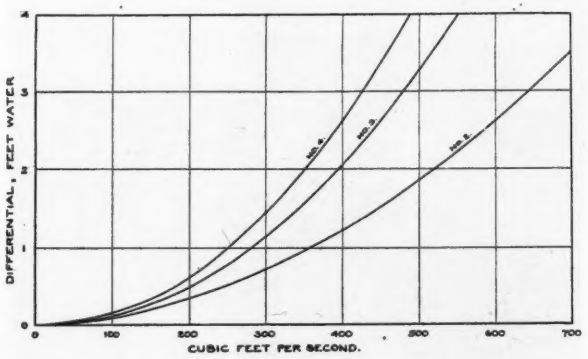
These devices consist entirely of methods of utilizing pressure differentials which are stable functions of discharge and are developed by existing features of station design, care being taken to eliminate, as far as possible, friction components of the differential which are due to conditions that in time may change the rating. There are no installations of standard Venturi tubes for direct measurement but there is one case in service and one under construction in which small standard Venturi tubes are used in shunt pipe circuits for developing useful differentials from the flow induced in the shunt by the relatively small differentials existing in the turbine arrangement. These are familiarly referred to as "sub-venturi" installations.

All these devices, where used for quantitative measurements, have been calibrated either by individual tests or by comparison with a calibrated device in the same station. Where not calibrated, the indications of relative flow have been of great value in determining the efficiency curve of each unit in terms of per cent of maximum efficiency or other convenient ratio.

Wherever expedient, the piezometer orifices are provided in the form of the company standard orifice fitting, consisting of a heavy brass disc set flush with the surface of the waterway and provided with a 1/8-in. hole at the axis and standard pipe threads for connection to instruments. Figure 1 illustrates this fitting for use in cast pipe walls.

At Stations No. 2, 3 and 4, the turbines are twin, center-discharge, horizontal units set in horizontal, cylindrical, pressure casings, the penstock being connected axially at the end opposite the generator. The rear bearing of these turbines is placed in a small inspection-chamber, the upstream end of which is rounded. Figure 2 illustrates the location of the pressure orifices in these units. The upstream orifice pressure has a considerable impact component, while the downstream orifice pressure is lowered by the head due to increased velocity.

These orifices were originally 1/8-in. holes with 1/4-in. air cocks tapped into the outer sides for rubber tube connections. Later these were provided with close fitting brass plugs with 1/8-in. holes. The installation of these brass plugs increased the differentials by 25 per cent to 50 per cent. The differentials average about 3.5 ft. of water, being exponential functions of discharge, with exponents ranging from 1.88 to 2.13 for



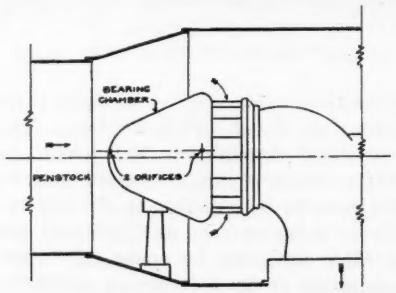


FIG. 2. ORIFICE LOCATION AND CALIBRATION, STATIONS 2, 3 AND 4

different units. These departures from 2.00 are definitely indicated by plotting the logarithmic paper the values obtained in a series of current meter and pitometer tests made in 1924 and 1925.

Recurrence of test evidence of deviation from a true function of the square of discharge indicates that such devices are extremely sensitive to orifice location and condition and necessitate a special calibration of each installation if reliable accuracy is sought.

MEASUREMENTS AT STATION NO. 5

At Station No. 5, the turbines are single, elbow-discharge, horizontal units with cast scroll cases. The 78-in. penstock in the basement turns up to the turbine

*From a recent report of the N. E. L. A. Hydraulic Power Committee.

through a 90 deg. elbow reducing to 48 in. at the turbine inlet. The venturi orifice fittings are installed in the 78-in. penstock and the 48-in. turbine inlet as shown by Fig. 3.

One of these venturi orifice sets was calibrated in 1920 by pitometer test. The two others were later calibrated by a method of comparison with the tested one. The differentials obtained for 350 cu. ft. per sec. are about 10 ft. of water and the test indicated them to be a straight line function of the square of the discharge.

The first installation at this plant consisted of the complete recording meter on one unit only and mercury manometers with indicating scale only on the other two units. The idea was to have the operators take routine readings of the manometer discharge indications for the station records but the results were so unsatisfactory that the recording instruments were installed on these units as well. The totalizing feature is the most important feature of these instruments for station record

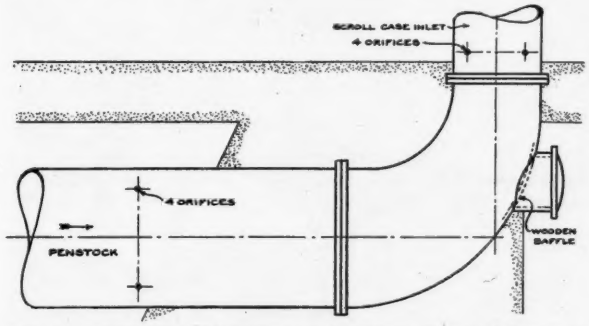


FIG. 3. ORIFICE LOCATION AND CALIBRATION, STATION 5

use, as it provides data for determination of average operating efficiency as distinguished from test efficiency.

Sherman Station Uses Sub-Venturi

At Sherman station, described in the July 1, 1927 issue of Power Plant Engineering, the one unit is a vertical turbine with plate steel scroll case. Just before connecting with the scroll case, the penstock reduces from 12 ft. to 11 ft. in diameter in a distance of about 6 ft.

This reduction develops a differential of about 0.6 ft. of water, which is too small to operate a recording instrument. By installing a 4-in. standard venturi tube in a 4-in. brass bypass or shunt between the 12 ft. and 11 ft. sections and by shielding the outlet of this pipe, a differential of 7 ft. of water is obtained with the same discharge, 1200 cu. ft. per sec. Figure 4 shows the arrangement of this sub-venturi equipment.

Provision of the shield on the outlet of these sub-venturi pipes is vital to the utilization of the capacity of the shunt pipe under the "main" venturi head. In this particular case, the installation of the shield increased the sub-venturi differential from 2.5 ft. to 7 ft. of water.

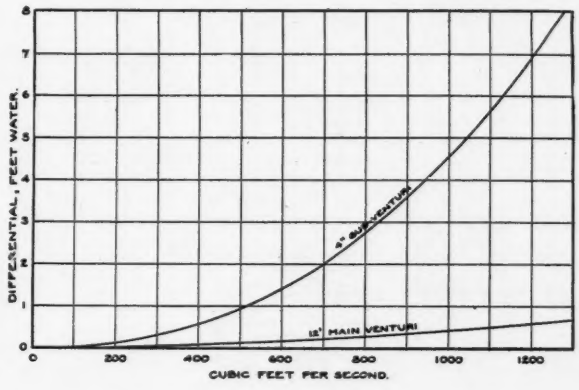
It is also important to design the sub-venturi pipe line for minimum head losses due to fittings and friction and minimum time change of friction which would change the rating. Suggested practice is the use of flanged brass pipe and fittings and special inlet and outlet terminals.

Differentials developed are shown by logarithmic plotting to be exponential functions of discharge with the notable difference that the "main" differential has an exponent of 1.96 as compared with 2.18 for the "sub-venturi." The calibration was made in 1927 by salt velocity test.

This unit is at present equipped with a standard mercury manometer but an indicating, recording and registering instrument may be installed in the future.

Searsburg Station Employs Venturi

At Searsburg the unit is a vertical turbine with cast-steel scroll case. Between the 78-in. penstock and



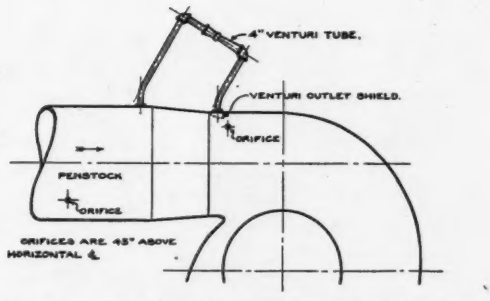


FIG. 4. ARRANGEMENT OF SUB-VENTURI, SHERMAN STATION

the 56-in. scroll inlet is a balanced needle valve, the valve making the reduction in diameters. The venturi orifices are installed in the penstock and in the scroll inlet.

Location of the orifices in this manner exposes the meter to the danger of full penstock pressure differential being applied when the valve closes. To avoid this, two 1-in. valves of the whistle pattern are provided and operated by direct mechanical connection with the valve plunger. One of these valves closes the discharge line, the other opens as a bypass, to equalize the meter pressures. Thus, when the main plunger valve has moved less than 10 per cent of its closing stroke, the meter is equalized and subjected to penstock pressure at both terminals, guarding against air accumulations during the shutdown period.

Maximum differential of 5 ft. of water is developed by this device with a discharge of 320 cu. ft. per sec. This differential is also an exponential function of discharge with an exponent of 2.00. The calibration was made in 1923 by salt velocity method. This station is

equipped with a standard indicating, recording and integrating instrument.

Vernon Station Presents Some Difficulties

Vernon Station, due to its type, has always presented obstacles in the way of testing, no features of the original design leading themselves readily to permanent calibration. In the period from 1921 to 1924 many tests and studies were made on the original three-runner tandem vertical units, with a view to obtaining information as to best operating conditions.

With the replacement of the old turbines of Units 1, 2, 3 and 4 by new single-runner turbines, trials

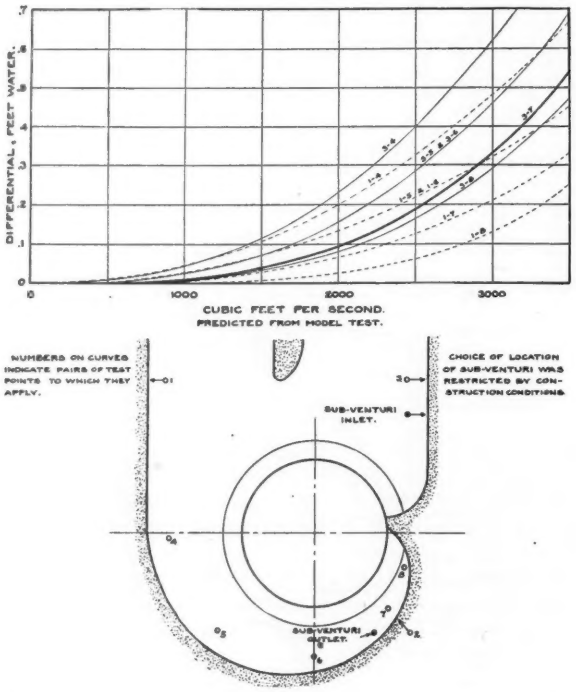

DIFFERENTIAL, FEET WATER.
CUBIC FEET PER SECOND.
PREDICTED FROM MODEL TEST.
NUMBERS ON CURVES INDICATE PAIRS OF TEST POINTS TO WHICH THEY APPLY.
CHOICE OF LOCATION OF SUB-VENTURI WAS RESTRICTED BY CONSTRUCTION CONDITIONS.
SUB-VENTURI INLET.
SUB-VENTURI OUTLET.

FIG. 5. ORIFICE LOCATION AND CALIBRATION, VERNON UNITS NO. 1, 2, 3 AND 4

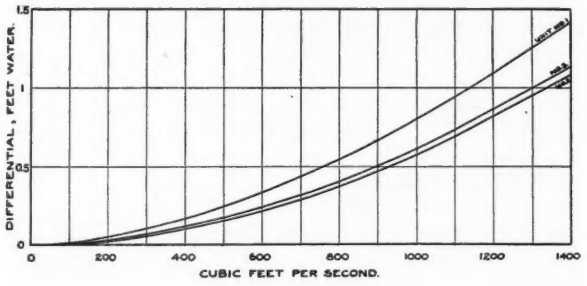
showed that differentials reaching 1.5 ft. were developed at diametrically opposite sides of the turbine pit cylinders. This follows from the design of the scroll, which is such that three-eighths of the total discharge passes on one side and one-eighth on the other. The areas and configuration of water passages thus produce an unbalance of velocities.

Temporary holes provided with cocks for rubber tubes were made at the selected points and the differentials were rated by current meter tests. These tests checked closely the curves predicted from the model tests and the detailed gate tests modified by the model tests were used as a basis for discharge curves for operating use.

Differentials are exponential functions of the discharge, with exponents ranging from 1.69 to 1.88 for different units. Temporary piezometer holes are to be fitted with standard orifice fittings. Figure 5 shows the location of orifices. The comparatively large differentials developed by this arrangement and the convenience of location indicate this as an excellent opportunity to install a sub-venturi outfit. Other considerations do not as yet justify the installation.

Bellows Falls Station

In considering means for flow measurement at the Bellows Falls Station, described in the August 15, 1928 issue of Power Plant Engineering, the successful use of the sub-venturi at Sherman gave reason to believe that this device will give good results here. Tests on a homologous model of this station intake and scroll case gave results that predict a maximum differential of over 0.6 ft. of water at the point selected for inlet and outlet for the 4-in. shunt pipe circuit. A favorable opportunity at Vernon permitted a measurement of the differential between points corresponding approximately to points 1 and 8 of the model test, Fig. 6. This test showed a maximum of 0.52 ft. at about 1700 cu. ft.



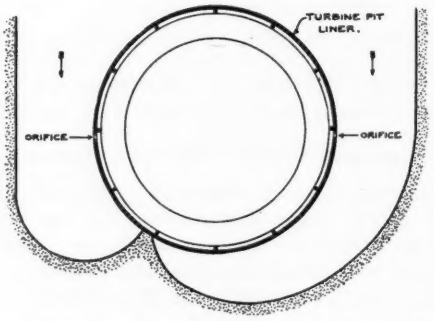


FIG. 6. LOCATION OF SUB-VENTURI AND PREDICTED CALIBRATIONS, BELLOWS FALLS

per sec. and was obtained with a deflecting shield over the scroll orifice, which increased the unshielded differential by about 0.1 ft. The points used were somewhat less favorable than those selected for Bellows Falls from the model tests.

Assuming a similar ratio between static differential and sub-venturi differential, as obtained at Sherman, the Bellows Falls installation should develop a sub-venturi differential of over 6 ft. of water, or about 6 in. of mercury. This will be ample to operate a standard instrument.

Method of test for calibrating these sub-venturi meters has not been determined. The canal in its revised form presents favorable conditions for tests by current meter or by the salt velocity method. Simultaneous use of both methods would be still more desirable.

Belt Joints Should Be Flexible

By W. F. Schaphorst

LEATHER BELTS are full of joints when they come from the manufacturer, but these are so well cemented that they are seldom thought of as being joints. In making a belt endless, the best joint is that made in the same manner as those already put in by the manufacturer. If he cements and rivets, the user should do likewise. If he depends on cement alone, the user should also do likewise.

To do their best, belts must be pliable, laterally as well as longitudinally; longitudinally on account of the cylindrical shape of the pulleys so that the belt can wrap itself about the pulley; laterally because of the crown of the pulley as intimate contact of the belt with the pulley is the secret of no slip. If the belt must be pliable, then, for good service, joints must likewise be pliable and the endless belt is best because it is equally pliable in every direction.

Joints other than cemented are good in so far as they approach the cemented joint. The ordinary rawhide-laced joint will not give as high efficiency, because the use of rawhide lacings requires that a considerable portion of the belt be cut away to make room for the lacing. If 20 per cent of the cross-section of the belt be removed for lacing holes, efficiency of the joint cannot be higher than 80 per cent. These joints are bulky. They are stiff. As they pass over the pulley, they raise part of the belt on each side of the joint from the pulley face and thus interfere with the desired intimate contact of belts with pulleys.

In the case of wire or metal fastener joints, the loss of strength is not so great as in the case of the rawhide lacing. As regards pliability, metal lacings are continually growing better and many makes are pliable both longitudinally and laterally. The hinge joint is a good example and, though not so pliable laterally as longitudinally, still is pliable enough for most drives.

Assuming that the efficiency of the three types of joints is: For endless belt 100 per cent, for metal lacing or fastener 95 per cent and for rawhide lacing 80 per cent, the corresponding belt width for transmitting equal amounts of power will be for endless belt 1, for metal belt 1.053, for rawhide lacing 1.25. If endless belts would cost $1000, we would have to pay $1053 for belts using metal lacing, and $1250 for those using rawhide joints in order to do the same work.

It must be remembered, however, that the cost of cemented joints will be considerably higher than that for making metal or laced joints and, if the belt is to be shortened at intervals as is often necessary, the metal-laced joint will be superior as an all-around proposition.

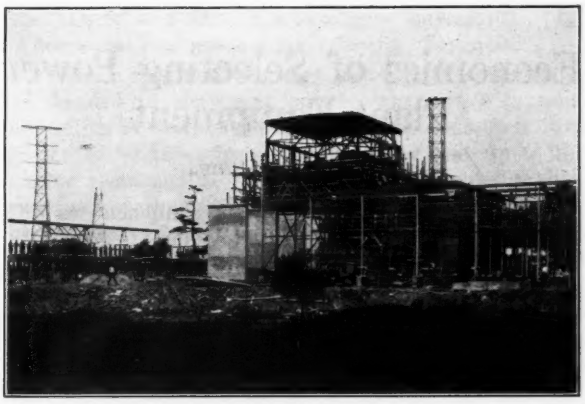
In estimating the cost of belting for a plant, it would be proper to take into account the saving possible by the use of the metal-laced or cemented joints. If $5000 is the estimated cost for belts using rawhide lacings, then, since the rawhide joint has only 80 per cent efficiency and the metal lace joint 95 per cent, the cost for the metal-laced belts could be taken as $5000 $\times$ 1.053/1.250 = $4220, which would show a saving in first cost of $780, in favor of the metal-laced joints.

After belts are properly put up and the best type of joint in use, the next step is to see that the belts are kept in the best condition at all times. They must be prevented from becoming hard and cracking, must be made or kept waterproof and the life must be maintained as long as possible by relieving initial tension or making initial tension unnecessary. A good belt dressing is essential and the best advice that can be given is to investigate under your own conditions and use belts that require as little dressing as possible.

New Switching Station for West Orange, N. J.

By A. C. Lescarboura

PUBLIC SERVICE ELECTRIC & GAS CO. of Newark, N. J., is rapidly carrying to completion the West Orange switching station now in the course of construction, as shown, at Mount Pleasant and Prospect avenues. The new plant is one part of Public Service's transmission program, formulated with an eye to meeting the future needs of the rapidly expanding New Jersey territory served by this progressive organization.



SWITCHYARD AND CONTROL BUILDING UNDER CONSTRUCTION AT WEST ORANGE

Consolidation of the electric systems of the Public Service Electric & Gas Co., the Pennsylvania Power & Light Co. and the Philadelphia Electric Co., when completed, will make one of the largest pools of electric power in the world. Not content with this, however, Public Service is developing a power ring around the northern part of the territory where the heaviest load demands must be met. This ring is to be the main artery through which the power from the stations at Kearney, Essex and Marion will be made available to consumers in the entire northern part of New Jersey. It will also serve as the artery by which the power obtained through interconnection will be distributed to customers in the same section. The three generating stations are on the east side of the ring, while the interconnection facilities are on the west side. The Athenia switching station, which serves the entire Passaic area, is already in service and the work on the switching stations at Roseland, West Orange and Metuchen is well under way.

Two high-voltage circuits of 795,000-circular mil

steel-reënforced aluminum cable on separate towers run from the Roseland Switching Station to connect with West Orange. The Roseland unit will thus serve to distribute power to West Orange; in addition, it is a junction point in the proposed interconnection with the Pennsylvania Power & Light Co. and the Philadelphia Electric Co.

At West Orange, the switching station is divided into two sections, one for the high-voltage lines and the other for the low-voltage lines. Interchange of power between these two lines is to be effected through two banks of transformers of 90,000 kv.a. capacity. The station is now being constructed to one-half of its ultimate size, as it will eventually house the equipment for four high-voltage and sixteen low-voltage lines.

In addition to the outdoor switching structures, a brick building 70 ft. long, 90 ft. wide and 65 ft. high will house the control equipment and operators for the station and provide the necessary space for overhauling and repairing the transformer units. To make the West Orange plant beautiful as well as useful, the entire site will be surrounded by a combination brick-post and ornamental-iron fence, tasteful lawns and shrubbery.

Economics of Selecting Power Plant Equipment

By Wm. P. Saunier

IN THE selection of power plant equipment, as with everything else, it is not wise to jump at conclusions. A study of the economics of a situation often discloses hidden factors which are not apparent on the surface. An excellent example illustrating the necessity of considering a piece of equipment as a complete unit is furnished by a recent investigation made by the writer into the respective merits of two different pumps for a specific duty. The study disclosed the fact that it was more economical to purchase a pump guaranteed for 81 per cent efficiency rather than one of 85 per cent.

In a certain station a circulating water pump was required for supplying a condenser with 18,000 gal. per min. against a total external head of 17 ft. of water and proposals were received from several manufacturers. After some consideration, two proposals, which appeared more attractive than the rest, were selected for more careful study.

One of these pumps was guaranteed under the required conditions for 81 per cent efficiency and operated at 390 r.p.m. while the other was guaranteed for 85 per cent efficiency and operated at 345 r.p.m.; the difference in quoted prices being $435 in favor of the lower efficiency pump. The required horsepower was 95.5 in the first case and 91 in the second and with a horsepower-year being valued at $40 the second pump appeared to be the better buy.

Horsepower saving of second pump over first = 95.5 — 91.0 = 4.5.

Annual value of horsepower saved = 4.5 × 40 = $180.

Annual saving capitalized at 13.5 per cent = 180 ÷ 0.135 = $1334.

From these figures, it appears that the more efficient pump was worth $1334 more than the pump of lower efficiency; but no consideration has yet been taken of the cost and efficiency of the motors required to drive the pumps.

In view of the character of the service required of circulating water pumps, a 125-hp. motor was decided upon. For speeds of 390 and 345 r.p.m., there is not only a difference in price of $200 but a difference in efficiency of about 2½ per cent throughout the operating range, the lower speed motor being both more expensive and less efficient. Evaluating this 2 per cent, the capitalized loss was found to be 0.025 × 91 × $40 ÷ 0.135 = $674.

Thus, the net capitalized value of the saving due to the higher efficiency of the pump and the loss due to increased motor cost and decreased motor efficiency was $1334 — $200 — $674 = $460. The more efficient pump was quoted $435 higher than the less efficient so that it still retained an advantage of $460 — $435 = $25, which was so slight as to be practically negligible.

As the two proposals appeared then to be of about equal merit, further considerations were sought for to effect a decision. Two points came to mind, the first of which was the axiom in power plant work that where two propositions are practically equal on an evaluated basis, that one should be selected which requires the smaller initial investment. The second point involves the guaranteed pump efficiencies and can be determined only from experience. The guarantee of 81 per cent efficiency for the higher speed pump appeared to be somewhat more conservative than the 85 per cent guarantee for the slower pump. In other words, it appeared more likely that the lower efficiency pump would exceed its guarantee on test by a greater margin than the higher efficiency pump. Both of the final considerations, therefore, were favorable to the lower efficiency pump, so this was purchased and subsequent tests showed an efficiency of 83 per cent, two per cent above guarantee, which seemed amply to justify the choice.

Two factors used in this discussion may need explaining. These are the value of a horsepower year, taken in this case as $40 and the factor used in calculating the capitalized value of the annual saving or loss, taken in this case as 13.5 per cent. The first factor is based upon the assumption that the average cost of generating a kw-hr. is 6 mills, including the fixed charges on the station.

$$0.006 \times 8760 \times 746 \div 1000 = \$39.2 \text{ or } \$40$$

approximately.

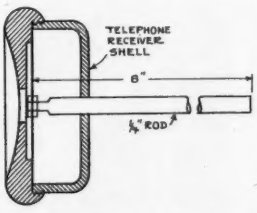
As to the second factor, 13.5 per cent is the rate of total fixed charges including 6 per cent for interest on investment, 5 per cent for depreciation and 2½ per cent for taxes and insurance. If 5 per cent of the original investment is set aside each year and interest on this sum is compounded annually at 6 per cent, an amount equal to the original investment will be accumulated in about 13½ yr. The use of the factor, 13.5, for the rate of fixed charges is today finding much favor among power plant engineers.

We judge ourselves by what we feel capable of doing, while others judge us by what we have already done.—Longfellow.

Stethoscope Detects Faulty Valve Operation

DEFECTS IN the operation of traps and valves may be readily detected by means of a stethoscope which may be quickly constructed with practically no cost. The one illustrated was made in 15 min. to check a trap suspected of leaking and has proven its worth many times since.

It consists of an old telephone receiver shell and a length of ¼-in. brass rod 8 in. long. The inner mechanism of the receiver was removed and a hole drilled in the center of the rear of the shell so as to fit the rod snugly.



STETHOSCOPE CONSTRUCTED OF OLD TELEPHONE RECEIVER FORMS HANDY INSTRUMENT FOR DETECTING IRREGULAR SOUNDS

The end of the rod was filed down and an 8-32 thread formed on the end for about ⅜ in. A hole punched in the center of the diaphragm permitted the threaded end of the rod to pass through it and two nuts were put on as shown.

The magnification of weak sounds by means of this instrument in power house equipment is really startling. Its use is much more satisfactory than the cruder and more common method of holding an iron rod or stick of wood between the teeth.

Philadelphia. THOS. W. BENSON.

Cooperation in the Power Plant

MR. RAWSON'S ARTICLE on page 1009 of the September 15 issue brings to my mind a similar system which was used in two other power plants with considerable success for a time. He states that the system probably would not work well in all power plants and in this he is quite correct as especially is this true for states having license laws.

In his case, it seems that the managers are in the habit of starting men at the top and then working down from turbine room to boiler room. This system does work for a while but eventually the men become discontented and more or less jealous of each other and after a year or so it becomes necessary to select the best qualified men and to place them in some permanent part of the plant, as the others, having become discontented, leave to accept other jobs.

In one plant where this plan was practiced for about 2 yr., even the repair mechanic secured employment elsewhere. The engineers remained only long enough for their turn at the boilers and stokers to arrive and then quit. There was a vacancy at all times in this plant and men were obliged always to work double watches or three watches in succession before being relieved. This created greater discontent and friction because the men who had become qualified as all-around men considered that they were doing as much work as the others and should accordingly have equal pay. When equal pay was not forthcoming, they quit.

When a new chief engineer took charge of the plant, he decided to change it but he was met with some opposition at first, as the men who had done their turn in the boiler room insisted upon being sent up to the engine room again. This compelled the chief to hire new men permanently for the boiler room with the understanding that they must work and study to qualify for promotion and higher pay. Each one settled in his place, after that, to learn and work as best he could, bringing about a congenial spirit amongst the force which developed not only a perfect coöperation but also a general fraternizing among the men for the purpose of qualifying for higher places.

Some succeeded in advancing while others were anchored at various levels due to limited education which prevented them from proceeding higher. These could have attended night schools, but as they became fairly contented with their pay they remained. In this plant, as in many others, it was necessary to have some one to substitute when an engineer was absent and either one of the repair men or water tenders who was of the qualified type was substituted. Some fireman was raised in his place at the same time.

This continued for several years, then business took a prosperous turn and created a greater demand for engineers and firemen and the men sought other jobs at higher pay. New unskilled men were brought into the plant, licensed firemen were in great demand and unskilled oilers were used and only oilers, repairmen and coal passers could be hired unless they had licenses.

There was much repairing, overhauling and cleaning to be done on pumps, condensers and engines. Discontent arose among this organization because the men wanted experience but did not know how to get it. The chief formed them into group classes so that they could be placed on different watches and when a boiler was washed out they all had a chance to do some of the work and learn something of boiler construction and care. The same was true with other apparatus even to

setting the valves of the engine. Engines were dismantled, piece by piece, and the connecting rod brasses and main bearings cleaned and scraped; cylinder heads were taken off and pistons examined and recentered and crossheads were adjusted. After about 2 yr. of such practice, the plant was in excellent running condition.

By this time, several of these young men had received licenses and some had failed. Discontent and jealous friction again set in. Those who had received license took employment elsewhere where they received higher pay. A slump in business put a large number of licensed men on the market and the promotion system was put in force again and coöperation and harmony reigned once more for a time. One husky oiler had been asked why he did not get a fireman's license so that he could substitute in the boiler room. He replied "what, me! to work double watches and break my neck?" He was getting one dollar more a week than the fireman but he worked one hour longer a day. He was, however, satisfied and insisted that the coal passer should be taught firing and promoted.

There is a general belief among power plant men that men should start at the bottom and work up as they develop and take greater interest in the business. There is always somebody willing to fill any vacancy in the lower grades and this gives the understudy a chance to qualify. Every man will work for higher pay but none will stand for demotion.

This system, I believe, is the best in the long run. License laws seem to favor it; as engineers are responsible for safety to life and property, they should know the business from the bottom up in order to assume properly such responsibility. Many men may not have the physical strength to do heavy firing, although such men may become good engineers but for such men there are small steam plants where they may obtain their firing experience so that afterward when starting work as an engineer in a new power plant, it is only necessary for them to trace out the pipe lines and valves in the boiler room in order to advise the boiler room force in cases of emergency.

Promotion on the basis of merit is, I believe, a more effective way to promote interest in the plant than by starting men at the top and then dropping them back into the boiler room. Engineers in licensed states are usually all-around men and should not be set back except for disability or lack of ability.

Cambridge, Mass. R. A. CULTRA.

Cleanliness and English Aid in Advancement

AS A GENERAL THING, the first place I glance at in your magazine is the Editor's column and I would like to offer a little comment with your permission.

It was my privilege to serve an apprenticeship in a steam plant where the machine shop cut quite a swath. I had to be able to cut a perfect thread on the lathe and do a passable job on the shaper before I was allowed to stop or start the engine. We also had to know whether the pitch on a machine bolt of half-inch diameter was twelve or thirteen. It is rather hard to make an old timer believe that the young engineer of today who knows not the first rudiments of the machinist's trade is the better man.

Now, about the language of the power plant. Whereas the dollar talk is O. K. and necessary, I was taught that, to bring the profession up to a proper standard, it was necessary to enter the office, when sent for or otherwise, with perfectly clean hands and face and a clean collar to boot. It is all right for the scoffers to say "pshaw" but the fellow who followed the foregoing advice is the fellow who is today superintendent of the plant. And a cultivation of his English does not harm the engineer any more than it harms the banker.

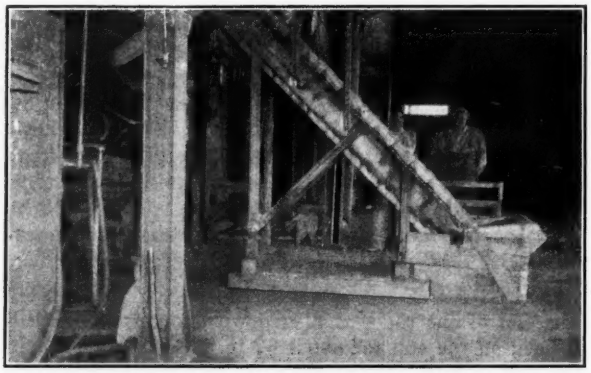
Perhaps all of this may be beside the question, but I have followed the game for 30 yr. I have seen the dirty and the clean engineer, the engineer who starts and stops an engine and the engineer who builds.

I hope that any young engineer who may read this will try to learn the practical end of repairs and to be able to tell in real English how it is done.

New York City. JOSEPH BROWN.

Discarded Conveyor Aids in Stoking

AMONG THE SIX boilers in our power plant is a 500-hp. water-tube boiler which is served by an underfeed stoker whose coal hopper is extremely high. As this



CONVEYOR MADE OF DISCARDED PARTS SERVES WELL IN FEEDING BOILER

boiler required considerable fuel, much effort was expended by members of the boiler room force, as well as by some of the under executives, to convince the chief executive of the factory of the need and to move him to purchase and install a conveyor for this purpose but all such effort was unsuccessful.

In an effort to solve our problem, I finally stumbled upon the buckets and chains of a discarded conveyor that had been used in the manufacturing plant. After rigging this up as shown in the picture, with a wooden box for the feed and a framework of steel channel bars found around the plant, the conveyor was connected to a small electric motor and is now serving admirably in lifting the coal from the feed box, into which it is shoveled by hand, to the hopper of the stoker.

Chicago, Ill. R. B. WARD.

Corrugated Gaskets May Be Reclaimed

PRACTICALLY ALL high pressure steam plants carry a stock of corrugated copper-asbestos gaskets. Such gaskets allow a small amount of expansion and contraction in the flange joint, and can be removed and re-used,

if proper care has been employed when they were origginally tightened up. After having been re-used several times, however, such gaskets become hard and brittle, due to the constant heat and compression. When they get in this condition they are usually thrown into the copper junk box.

Such gaskets, especially those of large size, are easily worth the trouble necessary to make them fit for re-use, although the flange bolts will have to be made much tighter than is necessary with new gaskets and the amount of expansion and contraction possible will be considerably reduced. All that is necessary to make such old, brittle gaskets soft and flexible is to heat them all over to a fairly good red color and then immerse them quickly in cold water. If there are any cracks or breaks in the corrugated copper covering, water may get inside, therefore, after dipping the hot gasket to anneal it for re-use, it should be set in a warm place to allow it to get completely dried out.

West Vancouver, Canada. JAMES E. NOBLE.

Belt Saved by Stretching After Water Damage

A WATER PIPE burst adjacent to the wheel pit of a steam engine and several inches of water collected in the pit before the pipe could be repaired. Some bricks were washed into the pit and the edges of the lap-ends of the engine belt were soaked loose and "scuffed up" by contact with the pieces of brick.

As soon as possible, the water and bricks were removed. It was then found that half a dozen lap-ends had been soaked and rubbed loose and it appeared that the leather had shrunk so that the ends, when smoothed out, would not cover the laps as they should.

After shutting down on Saturday night, the engineer worked the curled-up laps with warm—not hot—water and tried to stretch them as much as possible by pulling and kneading them over and over again, working each lap in turn. In this way and especially by clamp pulling, the lap-ends were finally brought back to their original size and shape. To effect clamp-pulling, the engineer placed two flat pieces of steel on each side of the edge of one of the curled-up lap-ends. Then the clamp was applied to the two pieces of steel, after which as strong a pull as possible was exerted on the clamp, causing it to stretch the curled-up leather and smooth it back into shape.

After a few hours of stretching and pulling, the lap-ends were well smoothed out and as fast as each one was brought to shape again, it, and the place from which it had been torn, were scraped clean, warmed, coated with good glue and clamped fast between smooth pieces of board by means of an adequate number of wooden hand-screws. The last of the lap-ends were clamped soon after 12 o'clock Saturday night. By Monday morning, the clamps could be safely removed and the belt found to be as good as new.

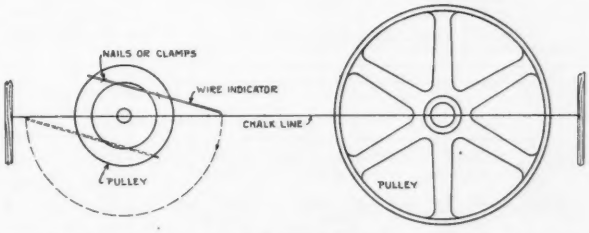
Some of the laps had to be clamped against the faces of the pulleys and for this purpose a veneer-built wooden box was procured from a dry goods store. Pieces of the veneer were cut a little larger than the laps, and fastened together at one side or edge by two small clinched nails. Six or eight thicknesses of the veneer were used in each of the "cauls" as such pieces used for gluing are called. The veneer cauls made with the grain crossed, clamped down easily to the pulley curvature and forced the tip ends of leather into place perfectly. All the cauls used, both those of veneer and those of plain board, were well heated before being applied to the belt and were put in place and clamped while they were as hot as the hand could bear. Such a degree of heat will not injure leather.

Indianapolis, Ind. JAMES F. HOBART.

Pulley Lined by Simple Method

IT OFTEN HAPPENS that pulleys are set close to bearings, making it almost impossible to square the shaft to a line, especially when the pulley is uneven at the edges. Motor pulleys are always set close and are irregular at the rim.

I find that the quickest and most accurate way to line up such pulleys is to clamp a piece of heavy wire to the edge of the pulley, if it happens to be of iron, or, if the pulley is made of wood or paper, two nails or staples may be used to fasten the wire. The wire should be as long as convenient, as the longer the wire the greater the accuracy. A wire 2 ft. long, bent slightly at the end, so that it will just tip a chalk line,



WIRE FASTENED TO PULLEY INDICATES ACCURACY OF ALINEMENT

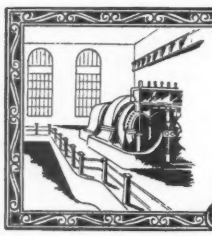
stretched parallel to the large pulley face as shown in the sketch, serves very well.

Tipping the line at one side of the pulley and then rotating the pulley by hand until the extended wire is at the opposite side of the pulley will indicate how much the pulley is out of alinement and the machine or motor can be shifted slightly. The alinement should be again tested and adjustment made until the indicator tips the chalk line equally on both sides as the pulley is turned. Care should be taken to see that all end play of the shaft is eliminated by holding it against one of its bearings.

This simple method avoids all doubt about alinement. I find it satisfactory to set small pulleys or motors or other machines about 1 deg. in advance of alinement so as to allow for slack in machines and pull of belts.

Knoxville, Tenn. HENRY LEOPOLD.

WORK has been started by Mountain States Power Company on 70 mi. of 33,000-v. transmission line extending from Lovell to Worland, Wyoming, by way of Greybull, in order to deliver power from the transmission system of the United States Reclamation Service, now serving Lovell, to the towns of Greybull and Worland, according to C. M. Brewer, vice-president and general manager of Mountain States Power Co.



QUESTIONS AND ANSWERS

Transformer Connections

IN OUR PLANT, we have six transformers which I wish to connect up for three-phase parallel operation. This bank of transformers will be supplied from a 13,200-v. feeder.

As these transformers on the high-tension side are only 7500 v., a star-delta connection will have to be

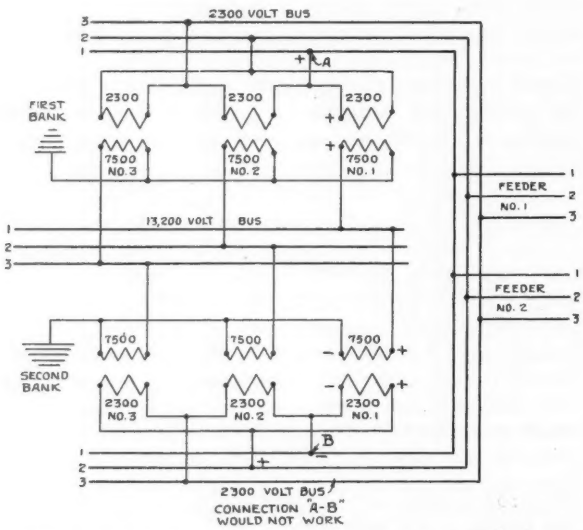


FIG. 1. WRONG CONNECTIONS WOULD CAUSE SHORT CIRCUIT BETWEEN TRANSFORMERS

used. I wish to connect the high-tension side back to back as shown in Fig. 1 and use a 2300-v. bus to take care of the low-tension side connecting my two feeders to this bus. I wish to use this back to back connection on the high-tension side without crossing the wires, dropping down to the transformer bank from the 13,200-v. feeder so that I will have No. 1 transformer opposite to No. 1 line; No. 2 transformer opposite No. 2 line and No. 3 transformer, opposite No. 3 line. Disconnecting switches will be used to disconnect the separate banks of transformers. These transformers all have the same characteristics and rating and all were built by one company.

Will you please check up my wiring connections?

H. P.

A. We have gone over the connections carefully and feel certain that those we suggest are correct. You will note that there is some change from your diagram, Fig. 1, as we found, in checking the polarity of the transformers, that your connection would give you trouble.

Considering transformer No. 1 in the first bank, we have added plus signs to indicate positive polarity on transformer No. 1. Assuming that the instantaneous voltage on high-voltage bus No. 1 is positive, you would have a positive high-voltage terminal and opposite the high-voltage terminal would be a positive low-voltage terminal. This would indicate that low-voltage bus bar No. 1 would be positive.

Now considering transformer No. 1 in the second bank of transformers, you will note that in your sketch, if we consider the polarity in the same way, from high-voltage bus No. 1 to the high-voltage terminal will be positive, as in the previous case. The low-voltage terminal opposite would also be positive and you connect this lead to low-voltage bus bar No. 2 instead of No. 1.

Taking the other end of the low-voltage side of your transformer and considering the instantaneous voltage as negative, as would be the case if the opposite end is positive, you will note that this would call for No. 1 low-voltage bus bar being negative, which must not be the case if transformer No. 1 in the first bank gives

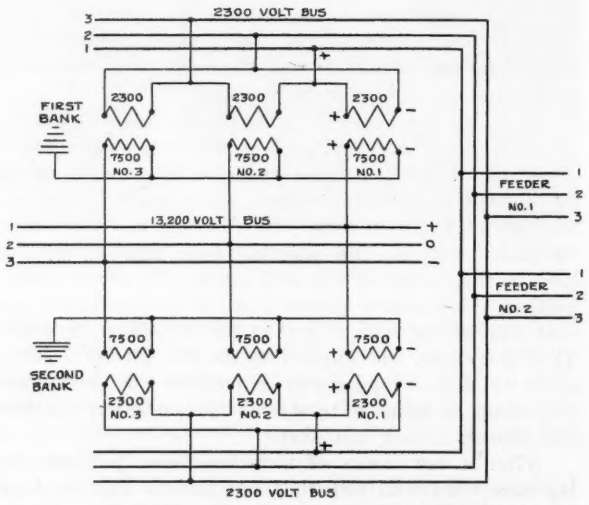


FIG. 2. CORRECT WAY TO CONNECT TWO BANKS OF THREE TRANSFORMERS FOR THREE-PHASE PARALLEL OPERATION

a positive voltage to this low-voltage bus bar. For this reason, we have made a new diagram of the connections, Fig. 2. This will give like polarity on each 2300-v. bus from each bank of transformers.

How Should Plant Heating Steam Be Charged?

REFERRING TO THE QUESTION of the correct method of determining the cost of steam as requested on page 846 of the August 1 issue, I wish to submit the following procedure.

From the wording of the question, I assume that the plant is equipped with the proper metering apparatus to determine the amount of steam generated and the amounts delivered to the several departments; that the coal is weighed and labor, supplies, repairs, etc., are properly recorded. Leaving out fixed charges, as they are usually kept by the cost department, we proceed as below.

First: to determine the actual cost to evaporate 1000 lb. of water for plant efficiency records we take the total amount of water evaporated and divide it into the total cost of operating the boiler room for a given period, say one month, if reports are on the monthly basis.

Second: determine the unit cost per 1000 lb. of water evaporated to be used in making charges to the several departments, we take the total of the meter readings, not including boiler auxiliaries or losses in the boiler room, and this total divided into the total cost of operating the boiler room, fixed charges not included, will be the price per 1000 lb. of steam delivered, to be charged to the several departments.

For example, take the total amount of steam generated in the boiler room for one month as 5,000,000 lb. and the total charges for operating the boiler room, not including fixed charges, as $2400.00; we shall have 2400 ÷ 5000 = $0.48 per 1000 lb. of steam generated.

Next take the total of the meters on the various lines, not including boiler room auxiliaries, which we will say comes to 4,000,000 lb. Taking $2400.00 for total cost as before, we have 2400 ÷ 4000 = $0.60 as the unit cost per 1000 lb. of steam delivered to be used in making charges to the various departments.

Waterbury, Conn. F. W. CARTER.

Air Compression and Air Buoyancy

AS A SUBSCRIBER to Power Plant Engineering, I would like to ask for a little information on two problems that I cannot solve.

1. An air compressor takes in 154 cu. ft. of atmospheric air per minute at a temperature of 70 deg. F. and delivers it at a pressure of 95.3 lb. per sq. in. gage and a temperature of 150 deg. F. What is the volume of the compressed air delivered per minute?

2. At a certain atmospheric temperature, air has a specific volume of 13.3 cu. ft. and hydrogen has a specific volume of 192 cu. ft. If a balloon bag which weighs 300 lb. has a capacity of 10,000 cu. ft., what is the greatest weight it could lift? E. J. S.

A. Using V_1 = original volume in cu. ft. = 154

P_1 = absolute initial pressure in lb. per sq. in. = 14.7

T_1 = original temperature absolute in degrees F. = 460.6 + 70 = 530.6

V_2 = volume at end of compression, to be determined.

P_2 = compressed air pressure = 14.7 + 95.3 = 110 lb. absolute.

T_2 = final temperature, absolute = 460.6 + 150 = 610.6 deg.

$V_1P_1 \div T_1 = V_2P_2 \div T_2$

$V_2 = V_1P_1T_2 \div (T_1P_2)$

$V_2 = 154 \times 14.7 \times 610.6 \div (530.6 \times 110) = 23.65$ cu. ft.

2. Weight of balloon and gas = 300 + (10,000 ÷ 192) = 352 lb. Weight of air displaced by the balloon (assuming the volume of the material of which the balloon is made as negligible) = 10,000 ÷ 13.3 = 750 lb.

Greatest weight the balloon can lift = 750 − 352 = 398 lb.

Safety Valve Size

KINDLY LET ME know what should be the size of the safety valve of a boiler operating under a pressure of 140 lb. absolute and evaporating 6000 lb. water per hour? J. B.

A. Kent's Mechanical Engineer's Handbook, 10th edition, page 992, gives the following formula for the pounds of steam a safety valve will handle per hour:

$W = 3600 \times p\ D\ L \times 0.96 \times 0.707 \times P \div 70$ or $D = W \times 70 \div (3600 \times p\ L \times 0.96 \times 0.707 \times P)$ where D = Inside diameter of valve seat; p = Ratio of circumference to diameter; W = Pounds of steam safety valve will handle per hour; P = Absolute boiler pressure in pounds per square inch; L = Vertical lift of valve disc, inches; 0.96 = Coefficient of discharge according to Napier's formula.

Then, $D = 6000 \times 70 \div (3600 \times 3.14 \times 0.1 \times 0.96 \times 0.707 \times 140) = 3.92$ in.

The A. S. M. E. Boiler Code, 1927, page 164, gives a simpler formula for 45 deg. bevel seats as follows:

$W = 110\ P\ D\ L$

or $D = W \div (110\ P\ L) = 6000 \div (110 \times 140 \times 0.1) = 3.9$ inches.

A 4-in. safety valve would, therefore, be the proper one to use.

Comparing these values with the tables of discharge capacities in Kent and the A. S. M. E. code, we find that a 4-in. diameter valve should be chosen. This agrees with the calculated diameters.

Calculations by Use of Logarithms

PLEASE INSTRUCT ME how to perform the following calculations by the use of logarithms.

1. Multiply 11.65 by 231 and divide the product by 2913.

2. Find the 5th root of the product of 78.23 by 113.5.

3. Compute the cube of 963.4 divided by 764.8. E. J. S.

A. Add log. 11.65 to log. 231 = 1.066326 + 2.363611 = 3.429937 which is the log. of the product. Subtract log. 2913 from this figure; 3.429937 − 3.464340 = 1.965597, which is the log. of the quotient. The quotient is then found to be = 0.9238. Logarithm values must be found from a table as given in works on trigonometry.

2. Add log. of 78.23 to log. 113.5 = 1.893373 + 2.054996 = 3.948369, which is the log. of the product. To extract the 5th root, divide this quantity by 5; 3.948369 ÷ 5 = 0.789673 which is the log. of the 5th root. The 5th root is then found to be 6.161.

3. Subtract log. 764.8 from log. 963.4 = 2.983807 − 2.883548 = 0.100259. To cube, multiply this quantity by 3; 0.100259 × 3 = 0.300777, which is the log. of the cube. The cube is then found to be 1.998.

EDITORIAL COMMENT

Research and Industry

"Progress of Civilization depends in large degree upon the increase and diffusion of knowledge among men. It is not merely a question of applying present-day science to the development of our industries, reduction in cost of living, eradication of disease and multiplication of harvests. We must add to our knowledge, both for the intellectual and spiritual satisfaction that comes from a widened range of human understanding and for the direct practical utilization of these fundamental discoveries. Improvement of some machine or process is of great value to the world. But discovery of a law of nature, applicable in thousands of ways and forming a permanent and ever-available addition to knowledge, is a far greater advance."

These statements, made by Mr. Hoover, at that time Secretary of Commerce, in December, 1925, were backed up by formation of a special board of trustees of the National Academy of Sciences to procure large funds for expenditure in pure science research. Several millions have been pledged. Industries contributing to the fund are not permitted to influence its administration for their particular interests but it is used to assist investigations and investigators with or without university affiliations. All results of such research are to be public property for the free use of all.

Even before this movement started, the U. S. Bureau of Standards had been mobilized as a scientific service organization. Research at the Bureau is largely of industrial character but projects undertaken are usually of a type not within the scope of private institutions. Part of the steam tables research is an example. Researches range from pure science to the most practical industrial applications, 989 men being on the regular staff.

Unless research in pure science keeps pace with industrial research, the creative forces of industry will starve. Realization of this fact led Mr. Hoover to work for expansion of the scientific and economic research of government agencies and coöperation with the community so that facilities of the Bureau are available to qualified research associates representing and supported by national organizations. Eighty-two such workers, representing 46 organizations are now at work in the Bureau on research programs, the results obtained to be available to all industries.

Those who know what has been and is being accomplished state that the research fund, which is not to be used as an endowment but will be spent directly in research, will bring returns of hundreds of per cent in the benefits to industry. Some of these will be simplification of processes and products, elimination of waste, better utilization of energy and industrial resources, greater stability of business, wider diffusion of knowledge and improvement in the welfare of the people.

Industry needs research, both purely scientific and applied, and will be repaid a thousandfold for such support as it gives to research workers.

Increased Electric Railway Trackage

During the year 1927, approximately 700 mi. of electric railway track was rebuilt. This represents an increase of about 100 mi. or 16 per cent over 1926 and although small from a mileage standpoint, it is significant in view of the pessimistic outlook predicted for electric lines when bus and auto competition first began to be felt.

Electric railways form a considerable portion of the total electric load in many sections and their decline would be a serious matter to many power plants. Fortunately many of the railway systems have been farsighted enough to realize that both types of transportation have applications in certain fields and can be profitably combined. With the control of the bus lines resting in the same hands that control the railroads, each can be confined to the field that it can advantageously and economically serve so as to reduce expense and eliminate cutthroat competition.

It is hoped that the increased rebuilding of track is an indication that the balance between the two services has been reached and that the electric railways see their way clear to undertake further expansion, a condition which will soon make itself felt in the power plant field.

When the Air Won't Follow the Trained Arrows

Signs of a rather wholesome sense of humor manifest themselves with increasing frequency in the engineering profession. For example, in a paper on methods of air distribution recently delivered before the A. S. H. & V. E., the author says, "It is best to begin with the admission that the air handled by the fans steadfastly refuses to recognize the authority of all the trained arrows that are placed on the blueprints to show it where to go."

In many cases there is a divergence between the theory of how our materials ought to act and the way in which they do act. To recognize this is merely to recognize the inherent limitations in men, materials and machines.

As a matter of fact it is this recognition of the fact that things are not always as they should be that brings about whatever progress we have made in engineering. If the air won't follow the trained arrows, the engineer doesn't sit back and say that the equipment isn't any

good. Instead, he tries to devise ways of making it do what he wants it to do.

It should be stated in no uncertain terms that men who design, operate and manufacture engineering equipment have been much less liable to self-deception than men in certain other lines of work. They recognize that superlatives and extravagant claims of what may be expected are vain, when subjected to the actual tests of plant operation. If the equipment has been designed with all the knowledge that is available, if it is soundly constructed and correctly operated and if it still does not give all the results demanded, mutual recrimination does no good. The usual procedure in such cases is for buyer and seller to get together in an attempt to find out what can be done to secure the performance desired.

Engineers, whether they are manufacturers, designers or operators, do not "kid" themselves much. It is not a question of honesty being the best policy or anything of that sort. It is simply that the engineer's mind is trained from the beginning to look at things as they are and he is unable to think in any other way.

Off Duty

Every dog has his day—a trite saying, perhaps, and one somewhat worn and marked with age, yet its obvious truth impels us to employ it in introducing this discussion of "color," for this is the day of color. The spectrum has come into its own at last. After years of seclusion in the mysterious depths of spectroscopes found only in a few physical laboratories and appearing in public only at the time of an occasional rainbow, the spectrum now comes forth boldly and we find it emblazoned on every broom handle and electric refrigerator.

"Note its beauty" reads an advertisement referring to a popular make of household refrigerator, tactfully ignoring reference to its mechanical virtues, "its colorful shades will harmonize with any scheme of kitchen decoration." The unit illustrated is garbed in an ensemble of honeydew pink trimmed with old rose. A gas range shown on the opposite page, not to be outdone by its more frigid kitchen companion is resplendent in a finish of passionate purple.

And so, from lead pencils and wash boards, to steam rollers and skyscrapers, the world today is a chromatic riot. Color—color in the home, color in business, color everywhere—it is the new talking point in advertising and the decorators are working overtime trying to produce new shades. Even the language is becoming colored. True enough, colored pajamas have satisfied the male species' secret craving for color for many years and behind the mysterious doors of his favorite lodge, he has been able to doll himself up in gorgeous raiment to his heart's content but today he is losing his sense of color modesty and issues forth in broad daylight in an array of color that would put a rainbow to shame. For many years, the pink whiskers of James Hamilton Lewis of Chicago were objects of rare interest in a monochromatic world but today they blend with the landscape in a way that must be trying to J. Ham's vanity.

Personally, we have been in favor of this rainbow epidemic. Startling at first, it has been a pleasant change and we hoped it would continue; however, we did not know all the facts. While the show is pleasant to behold, behind the scenes things, it appears, are not serene. The manufacturers, having started the fad, are now finding it beyond their control and, to state the plain truth, are having a heck of a time. Color, instead of being a refreshing dream, is proving a nightmare. A howl has gone up. Manufacturing costs are mounting; it is impossible to secure uniformity in shades; different localities require different colors; the colors in use are not fast.

Dealers, too, are having their grief. As reported in a recent number of the Magazine of Business, a lady in Evanston, Ill., who desired to have her kitchen appointed in robin's egg blue and who went to considerable expense in having imported Dutch ceramic tile set in her walls, found, when it came to buying a kitchen cabinet, that the best she could do was to get an off shade of blue. The plumbing, too, was an impossible blue and the gas stoves available were still of other blues! Imagine the poor dealer, running around trying to find a robin's egg blue kitchen cabinet to match the robin's egg blue of a mop handle!

Color, psychologists assert, has a definite bearing on our reactions and a certain executive, taking the cue, comes forth boldly and announces that color increases efficiency of production and relieves fatigue. Perhaps it does but not to a dealer trying to locate the right kind of robin's egg blue in a dustpan.

Out of this all, now comes the crying appeal from manufacturers, that colors be standardized. There are too many colors, it seems and the harassed maker of ranges or corkscrews as the case may be, cannot keep pace with the spectrum. Something should be done about it. This may not be a bad time to suggest that the two presidential candidates take up the issue. Let them stand for a revision of the spectrum; let them urge a purely American spectrum. Congress, with proper support, could, no doubt, dispose of the matter in a few days by making it unlawful for anyone to make a spectroscope producing colors other than red, white and blue. This suggestion is offered in a patriotic spirit.

In one instance, a manufacturer of ranges has compromised with the color fad by introducing color into only certain parts of his ranges. These parts are easily interchangeable so that the problem of suiting localities or of suiting a consumer's special taste is greatly simplified. An excellent idea but we have a better one, to wit; make all the stoves white but give, with each, a set of varicolored spectacles so that when the owner gets tired of looking at a red range, it will only be necessary to change spectacles and presto! a green range will appear. Color, after all, is only a matter of reflection or refraction.

All told, it is a trying situation and we shudder when we think of what will happen when color is introduced into the power plant field. Imagine the predicament of the unfortunate engineer whose pea-green unit pulverizer goes "west" just when the load comes on and who finds that the only repair parts available in town are an emerald green! The spectacle is too terrible to contemplate.

We hereby open our campaign for a simpler and cheaper spectrum.

National Fuels Meetings Held in Cleveland

SECOND MEETING SPONSORED BY THE A. S. M. E. IS ATTENDED BY ALMOST 800 AND IS CHARACTERIZED BY A LARGE ATTENDANCE OF MEMBERS FROM OTHER SOCIETIES

ON MONDAY, September 17, the opening session of the four-day Second National Fuels Meeting of the A. S. M. E. held in Cleveland, was called to order by Victor J. Azbe, chairman of the Fuels Division. After briefly reviewing the importance of fuel in our present day civilization, he extended a welcome to non-members and representatives of other societies.

Following this, he introduced Dr. Thomas T. Baker, president of Carnegie Institute of Technology, who delivered the opening address on "The Perils and Profits of Research." "Research," said Dr. Baker, "through industrial competition, is a peril to those who ignore it and a blessing to those who employ it." No longer does the scientist fear loss of dignity in applying his scientific findings to a practical end and, although through private laboratories, industry has to a certain extent usurped the place formerly occupied by university laboratories, he looks forward to a closer coöperation between the two in the future.

In the afternoon, two simultaneous sessions were held. Before one, the Fuels Characteristic Session, A. C. Fieldner, of the U. S. Bureau of Mines, presented a paper, "Constitution and Classification of Coal," Henry Kreisinger and B. J. Cross, of the Combustion Engineering Corporation, presented another paper entitled "Burning Characteristics of Different Coals." In the general session, "Progress Toward Direct Firing of Boilers With Producer Gas" was presented by W. B. Chapman, consulting engineer, and a paper dealing with the "Washing and Preparation of Coal" by H. D. Smith of the Majestic Collieries Co.

COAL CLASSIFICATION BEING ATTEMPTED BY THE A. E. S. C.

Mr. Fieldner reviewed the recent action of the American Engineering Standards Committee in taking up the classification of North American coals. After reviewing the various classifications such as used by the chemist, paleobotanist and geologist, he outlined the probable considerations that will be kept in mind in the new classification. Two basic principles are at the bottom of all methods: first, the intrinsic chemical and physical properties of the coal itself and second, the purposes for which the coal can be used to good advantage.

For practical purposes, Henry Kreisinger divided coal into four groups, using Ralston's Chart, which utilizes the carbon, hydrogen and oxygen contents of ash free coal, to show the relation of these four coals to each other. This paper is abstracted elsewhere in this issue.

Possibilities of using gas producers for steam generating purposes and the requirements of such a gas producer were sketched by W. B. Chapman. Cleaning and preparing coal is a considerable item to the coal producer and at present it is difficult for him to determine just how far he is justified in going. It has also been found that the better some coals are washed and the more the ash content is reduced, the lower becomes the fusing point of the ash. The reverse may be true of other coals while still others are unaffected by the process.

On Tuesday morning an Industrial Session and Heat Transfer Session were held simultaneously. In the former, "Industrial Furnace Efficiency and Economic Considerations" was presented by James H. Herron and "The Use of Fuels in Tunnel Kilns" by W. E. Rice, of the Bureau of Mines.

WATER CONDITIONING NOW COVERS ENTIRE STEAM CYCLE

In the Heat Transfer session, A. C. Danks, of Ashmead-Danks Co., described a patented cross baffling for use with vertical boilers for the purpose of removing restrictions and allowing easier flow of gases through the boiler. At the same session, Dr. R. E. Hall, of Hall Laboratories, discussed the "Present Tendency of Boiler Water Conditioning."

Flexibility is now the major demand of boiler water conditioning, high pressure demands are more exacting and the water conditioning now extends through the entire cycle in contrast with the past condition when it stopped with the furnishing of water of a certain residual hardness.

All phases, including protection against corrosion, caustic embrittlement and foaming, were covered by Dr. Hall, who ended with the following conclusions: "To make systematic water conditioning a reality, it has been necessary not to introduce new chemicals, not to specify equipment, but to define with exactness those relations for the contacting water which protect the surfaces from economizer or heater to turbine. Specific types of equipment for realizing the essential relations is secondary to their maintenance and is a matter of indifference from the standpoint of water conditioning so long as it is sufficiently flexible to permit simple and dependable maintenance."

Complete and accurate records are a necessity, as he pointed out in the discussion which followed. The best that can be done at present is to follow the recommended conditions of alkalinity to prevent corrosion and ratio of sodium sulphate to total alkalinity to guard against embrittlement.

In the afternoon, a general Session and a Powdered Fuels Session were held. In the former F. R. Wadleigh, consulting engineer, outlined the possible avenues of productive research on coal, and F. M. VanDeventer of Henry L. Doherty, presented a paper "Determination of the Economic Value in the Selection of Power Plant Equipment." This paper, which is the continuation of a paper presented at last year's meeting, reviews the customary procedure in obtaining competitive bids and discusses the commonly used criteria of relative values. The author concludes that the only correct methods of evaluating bids are those equivalent to determining the minimum sum of fixed and operat-

ing charges taking into account price, performance, other operating costs and the influence upon other plant equipment. Such considerations as return on the investment, time required for savings to liquidate first cost, cost per unit of weight, and capacity or surface, do not indicate economic value and should not be used in the evaluation of bids.

Pulverized Coal Session Creates Interest

At the Pulverized Coal Session, three papers were presented. Lincoln T. Work, of Columbia University, presented data on various types of coal pulverizing mills to show their relative performance. His investigation shows that the various principles of mill action make fuels of different fineness. The hammer mills produce relatively coarse coal with but little superfines; the roller mills produce widely differing fineness, depending upon specific mill action and plant conditions, while tube mills produce coal low in sieve mesh and high in superfines.

"Collecting Dust from Chimney Gases of Powdered Fuel Installations," by K. Toensfeldt, of the Combustion Engineering Corp., described some commercial types of dust collectors. All of these devices are more or less effective on the coarser particles but not so effective on the fines of under 300 mesh. In the discussion, some felt that this was not important but H. K. Ried, speaking from experience in the cement industry, felt that the real merit of the device depended upon its efficiency on fine dust, as this dust sometimes causes trouble at distances of 10 mi. Carbon particles are particularly hard to catch and he felt that properly designed cyclones were most dependable.

John Blizzard, of Foster Wheeler Corp., presented a general paper on the "Unit System of Coal Pulverizers for the Generation of Steam." In the discussion, E. H. Tenney was asked what to him, from his experience at Cahokia, was the outstanding feature of the unit system, and he replied that it was the ease of maintaining the mills; that is, a day for overhauling the new unit mills as against a four weeks' job on the large mills.

Railroad and Marine Sessions Add Diversity to Meeting

Wednesday morning three sessions were held. In the Railroad Session, at which J. M. Clark of the Southern Pacific Railroad discussed "Railway Practices in Utilization and Conservation of Coal" and Malcolm McFarlane of the New York Central Railway, the "Selection and Use of Fuels in Locomotive Practice." The Railroad Session was also held in the afternoon, when John C. Crawford, of the C. B. & Q. R. R. discussed the "Relative Values of Different Sizes of the Same Fuel in Locomotive Service" and W. J. Overmire of the Big Four Railroad discussed "Railway Practices in Utilization and Conservation of Coal."

Wednesday morning, before the Marine session, T. B. Stillman, of Babcock & Wilcox Co., presented a paper on "Pulverized Coal Firing of Marine Boilers" and George B. Richardson, of the Bethlehem Steel Co. discussed "Oil Firing of Marine Boilers."

In the morning session on Refractories and Stokers, Dr. C. F. Hirshfeld and W. A. Carter, of the Detroit Edison Co., outlined the work and some of the findings of the Refractories Committee of the A.S.M.E. Conditions to be met in this field were practically unknown and no scientific data were available when the work was started. Misconceptions regarding firebrick are many and it is hoped that the work of the committee will produce some usable results. In carrying on this work, Dr. Hirshfeld said that they were often asked why, in the face of increasing water wall surfaces, they felt it worth while to carry on refractory research. The answer is simply that they do not consider the use of water walls, either now or for many years, to be universal practice. "Stoker Advantages and Disadvantages" were also discussed by Theo. Maynz at this session in a paper dealing largely with the superiorities of the underfeed stoker for practically all conditions.

Central Station Session Brings Out Discussion

In the Central Station Session held Wednesday afternoon, three papers were presented; "Developments in Recent Design of Stoker Fuel Equipment," by Jos. G. Worker and Jos. S. Bennett, of the American Engineering Co.; "Progress in Central Station Use of Pulverized Coal," by E. H. Tenney, of the Union Electric Light & Power Co., and "Present Status of Furnace and Burner Design for the Use of Pulverized Coal," by E. G. Bailey, of the Fuller Lehigh Co.

In his discussion, Mr. Bailey went briefly into some of the many factors affecting burner design and reviewed briefly some of the designs that have been developed and are in successful operation. The stoker paper by Worker and Bennett reviewed and gave data on some recent installations made by their company.

The paper by Mr. Tenney contained much interesting cost data on the various installations at Cahokia. He showed that mill maintenance had been cut from 10 and 11.6 cents per ton of coal in the large, to 7.2 cents in the unit mills; that the boiler efficiency has been increased several per cent and the power consumption of the mills decreased in the new or No. 3 section of Cahokia. At the same time, the relative investment, based on capacity, has been cut in half.

The last day of the meeting was devoted entirely to Smoke Abatement, H. B. Meller of Mellon Institute presenting a paper on "Damages Due to Smoke" and Victor J. Azbe, consulting engineer, Part II of his paper, "Smokeless and Efficient Firing of Domestic Furnaces" at the morning session, while K. Kugel, Deputy Smoke Commissioner of Cleveland discussed "Problems and Methods of Smoke Abatement Work" at the afternoon session. This paper was followed by a general conference on smoke abatement.

In addition to the professional sessions, an extensive series of inspection trips was arranged, the four principal ones being the Fairmont Pumping Station, Avon Station, American Steel & Wire Co. plants and the Cleveland Airport. One of these trips was held each day, beginning Monday.

Installation of an additional 30,000-kw. turbine-generator at the Horseshoe Lake station at Harrah has been completed and the unit was placed in service September 1. The original Horseshoe Lake station consisted of one 15,000-kw. unit and one 20,000-kw. unit and with the completion of the new unit, this station has a capacity of 65,000 kw.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

Welded Line Supplies Union Terminal Building

UNION TERMINAL building at Cleveland, Ohio, one of the largest and most modern passenger terminals in the world, is to be heated by steam generated at the plant of the Cleveland Electric Illuminating Co. To get the steam from the generating station to the Terminal Building, it was decided to carry it through an all-welded high-pressure pipe line, located in a tunnel 45 ft. under street level. The job was installed by A. R. Brueggeman Co. of Cleveland.

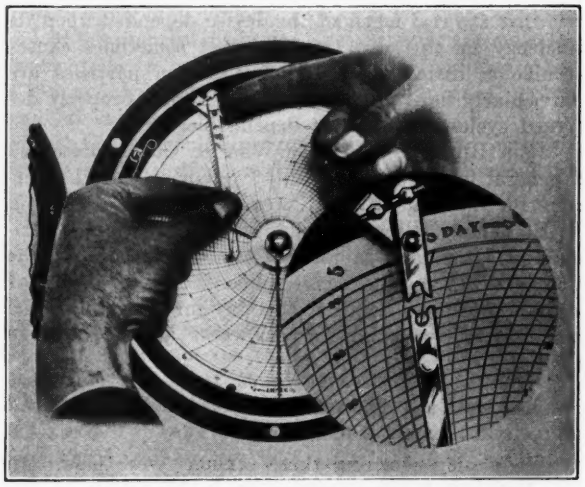
WELDING PLUG INTO END OF PIPE FOR HYDROSTATIC TEST OF WELDED STEAM LINE

Total length of the line was 1800 ft.; it was of 16-in. outside diameter pipe having a wall thickness of ½ in. and 352 lineal ft. of seam was welded. The pipe came in 20-ft. sections and each joint was beveled and welded by the oxy-acetylene process, using 3½ per cent nickel welding rods.

This line was designated for a working pressure of 125 lb. per sq. in. but to insure its absolute safety, it was tested at frequent intervals at a pressure of 525 lb. per sq. in. Testing was done by welding a plug into the end of the partially completed line and pumping water into the pipe until the required pressure was reached. After testing, the plug was cut out and an expansion joint welded in its place. Under this heavy pressure, only two pinhole leaks developed in the welds and even these pin holes did not appear until a pressure of 425 lb. had been reached. The picture shows the plug being welded in place, prior to one of the hydrostatic tests. A tensile strength test of a fully welded joint showed 45,664 lb. per sq. in. but this was inconclusive, as the test specimen broke in the pipe outside of the weld, indicating that the strength of the weld was considerably greater.

Detachable Pen Arm for Foxboro Instruments

FOR USE on the Foxboro recording instruments, the patented, detachable pen arm with open end, as shown, has been developed by The Foxboro Co., Inc., Foxboro, Mass. It is designed to be quickly replaced,



NEW PEN ARM IS DESIGNED FOR EASY INSTALLATION

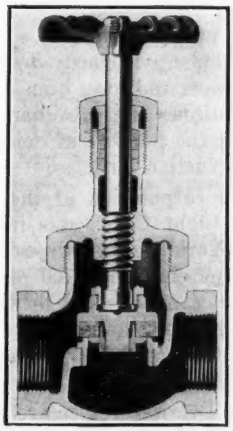
if bent or broken, by detaching the pen arm with the finger nail and slipping on a new one. The insert shows the construction of this pen arm and how it can be slipped into place. The lower end of the pen arm is open to facilitate the removal, cleaning and inking of the pen and to keep the pen arm clean.

Bronze Valves for 250-lb. Pressure

NEW LINE of bronze valves with renewable resilient disc for 250 lb. steam working pressures is announced by Jenkins Bros., New York City. The disc, being more resilient than the metal, readily conforms to the seat and is intended to insure a tight valve without regrinding. The line comprises globe, angle, cross

and horizontal and check patterns, furnished screwed or flanged in sizes ranging from ¼ in. to 2 in. The globe, angle and cross patterns are furnished with renewable seat rings. The bonnet screws over the body, a construction designed to add strength. The bonnet seat joint is rounded to provide strength and at the same time to allow easy removal of the bonnet.

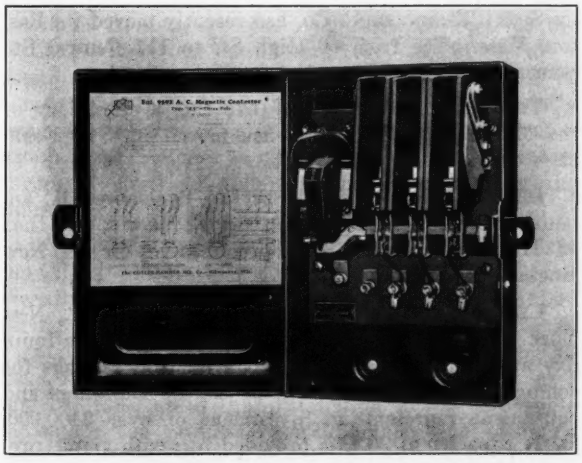
Other features of the globe, angle and cross patterns include: non-heat hand wheel of malleable iron; bronze gland to prevent leakage around the spindle; deep stuffing-box generously packed with asbestos ring packing; and manganese bronze spindle with large, powerful threads, all of which are in contact with bonnet threads when valve is closed.



RESILIENT DISC IS DESIGNED FOR TIGHTNESS AND EASY RENEWAL

Magnetic Contactors for Control of A. C. Circuits

COMPLETE NEW LINE of alternating-current magnetic contactors, designed especially for controlling lighting and power circuits automatically and for miscellaneous applications, is announced by The Cutler-Hammer Mfg. Co., Milwaukee, Wis. Construction of these new contactors includes high-efficiency, hammer-head-type magnets with self alining armature, continuous duty magnet coil, hardened steel bushings, tin-dipped, solid-copper contacts, magnetic blowouts and chimney-type arc shields. In addition, the large size contactors have the magnet frame supported on a spring plate to absorb the shock of the magnet on closing.

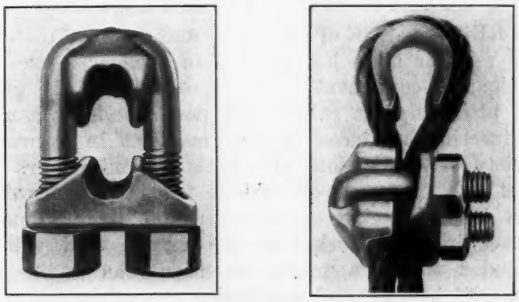


THREE-POLE, 40-AMP., A.-C. CONTACTOR

Two or three-wire control can be used. With two-wire control, low-voltage release is provided and with three-wire control, low-voltage protection is provided. There are two, three and four-pole types with an ampere capacity ranging from 20 to 150 amp. The contactors are supplied mounted in a split enclosing case or on a slate panel for switchboard mounting.

Eureka Cable Clips

FOR USE with all sizes of wire rope and messenger strand, the Eureka cable clip shown herewith has recently been placed on the market. It consists of four parts; the U-bolts, nuts and two grooved jaws to grip the cable. It is designed so that any length of wrench can be used in tightening, so that the cable is not distorted or cut and so that clips can be staggered on the cable. Surfaces of the plates are grooved for the lay of the cable. These clips are made in all sizes, of steel or bronze, by Eureka Metal Products Corp., North East, Pa.



TWO VIEWS OF EUREKA CABLE CLIP, SHOWING METHOD OF ATTACHMENT

Duquesne Light Co. to Have New 60,000-Kw. Station

BYLLESBY Engineering and Management Corporation announces that authorization has been made for construction of a 60,000-kw. steam electric generating plant in Pittsburgh, for the Duquesne Light Co., one of the Standard Gas and Electric Company group of utilities. The cost for the initial installation of this new station will be approximately $9,000,000 and it will be located adjacent to the Duquesne Light Co.'s switch house and south of the present power station, on Brunot Island.

Power house building will be large enough to house two 60,000-kw. turbine-generators and six boilers but at present only one 60,000-kw. unit and three boilers are to be installed, provision being made for future extension to the station. It is estimated that the completed station will cost $13,500,000.

The main building will consist of an electrical gallery and offices, a turbine room with spaces above the roof trusses for station auxiliary electrical equipment, and a boiler room. A circulating water pump and screen house will be located north of the present switch house on the bank of the Ohio River. The building will be of brick, tile and concrete construction with steel frame supported on concrete piling. The exterior of the brick wall of the building will be of face brick similar to the present Brunot Island switchhouse.

One coal tower having a capacity of 200 t. per hour will be installed for the purpose of unloading barges from the main channel of the Ohio River. The coal tower structure will contain a receiving hopper feeding a 200-t. per hr. crusher, the crusher discharging into an inclined elevated belt conveyor which will run from the coal unloading tower to a point approximately 75 ft. northeast of the present switchhouse.

According to Halford Erickson, vice-president in charge of operation, work of drawing the plans for the new station will start immediately. Actual construction work will start this year and continue through 1929.

Power Shows Offer Opportunity for Review of Progress

GREATER USE of machinery and power in industry and the home has resulted in a wider interest in mechanical equipment. This is reflected in the growing attendance at exhibits of power and mechanical engineering. Interest is also manifest in a greater variety of applications of machinery and power. To meet this the scope of exhibits has been widened so that in the coming exposition at the Grand Central Palace in New York City the marine field will be included and even greater attention than in the past given to heating and ventilation, to refrigeration, to safety appliances and to shop machinery.

Investments in the industrial and power fields are increasing in importance and executives of financial institutions are realizing the need of first-hand knowledge of industry. They are awakening to the importance of studying equipment and methods so that they may have a basis for judging the soundness of securities offered and are using the machinery shows as one means of making such study.

In addition, the meetings of the American Society of Mechanical Engineers, the American Society of Refrigerating Engineers and the American Institute of Chemical Engineers in New York during the week of the exposition, Dec. 3 to 8, will bring together a large body of professional men who are vitally interested in keeping posted on the latest improvements in industrial equipment and methods. Realizing this, exhibitors will, naturally, put in evidence their latest developments and improvements.

Opportunity is offered, therefore, at such exhibitions, for contact and acquaintance with leaders in a great variety of fields on both the engineering and the equipment sides of industry.

AUTHORITY HAS BEEN granted the Cedar Falls, Iowa, municipal power plant to construct nearly 24½ mi. of transmission lines and laterals between Cedar Falls and Finchford, carrying 6200 v.

Allied Power & Light Corp. Acquires New Holdings

AS ANNOUNCED last May, the organization of Allied Power & Light Corp. (incorporated under the laws of Delaware, May 5, 1928) was effected to consolidate the interests of Hodenpyl, Hardy & Co., Inc., Stevens & Wood, Inc., and other interests.

Allied Power & Light Corp. will be financially interested in electric power and light and other companies and already has acquired substantial holdings of stock of Commonwealth Power Corp., Penn-Ohio Edison Co. and other public utility companies. Hodenpyl, Hardy & Co., Inc., and Hodenpyl, Hardy Securities Corp. have discontinued business and have been dissolved. Stevens & Wood, Inc., continues as a subsidiary of Allied Power & Light Corp. for the purpose of doing a general engineering and construction business.

Later, another corporation of the same name, viz., Allied Power & Light Corp., was incorporated under the laws of New York for the purpose of pending management supervision services. All of the stock of the New York corporation is owned by the Delaware corporation. The principal offices of the Allied Power & Light Corp. and Stevens & Wood, Inc., are at 20 Pine St., New York City.

Officers of the Delaware Corp. are as follows: B. C. Cobb, chairman; R. P. Stevens, president; Jacob Hekman, Wm. H. Sawyer, T. A. Kenney, vice-presidents; H. G. Kessler, comptroller; E. E. Nelson, secretary and assistant treasurer; George Sprague, Jr., treasurer. The directors are B. C. Cobb, Jacob Hekman, Alfred L. Loomis, Horace S. Scarritt, R. P. Stevens, Landon K. Thorne, all of New York City, and J. T. Harrington of Youngstown, Ohio.

Officers of Stevens & Wood, Inc., are as follows: R. P. Stevens, chairman; W. H. Sawyer, president; B. F. Wood, J. W. F. Bennett, vice-presidents; H. M. Billingsley, secretary; E. W. Freeman, treasurer and assistant secretary; E. J. Lewis, assistant treasurer, J. W. F. Bennett, H. M. Billingsley, B. C. Cobb, T. A. Kenney, W. H. Sawyer, R. P. Stevens, B. F. Wood, all of New York City, comprise the board of directors.

News Notes

SPRAY ENGINEERING CO. has recently moved its Boston, Mass. office from 60 High St. to 114 Central St., Somerville, Mass.

THE MERCO NORDSTROM VALVE CO., a subsidiary of the Merrill Co., Engineers, has moved its San Francisco office to 343 Sansome St.

IDEAL COMMUTATOR DRESSER CO., Sycamore, Ill., announces the appointment of Albert E. Mace & Co., Inc., 93 Heath St., Boston, as representatives in the New England territory.

CHICAGO PNEUMATIC TOOL CO., 6 E. 44th St., New York City, has recently completed a large modern foundry at Franklin, Pa., where all gray iron castings for compressors and engines will be made. Buildings and equipment represent an investment of over $400,000. Daily capacity of 30 t. is provided for, with ample provision for doubling this tonnage. The company feels

warranted in making this expenditure because it makes possible complete supervision of every step entering into the manufacture of its products, from raw material to the completed machines.

THE FALK CORPORATION, Milwaukee, Wis., has recently appointed B. W. Rogers as representative for Akron, Ohio and vicinity. Mr. Rogers was previously associated with B. F. Goodrich Co. and prior to that with the Allis-Chalmers Mfg. Co. and will have his offices at 225 Central Savings and Trust Bldg., Akron, Ohio.

THE BROWN INSTRUMENT CO. has enlarged its Detroit branch quarters and is now at 576 Maccabee Bldg., Tel. Northway 0283-0284. R. W. Mayer is in charge as district manager.

M. H. DETRICK CO., Chicago, Ill., has recently appointed the Ash Engineering Co., Chamber of Commerce Bldg., Cincinnati, O., as representatives in that territory.

ROSS HEATER & MFG. CO., INC., Buffalo, N. Y., announces that it has opened a branch office in Philadelphia, Pa., under the direction of J. W. Spencer, Jr. with headquarters at 121 N. Broad St., Room 305.

AMES IRON WORKS, Oswego, N. Y., has recently appointed Joseph A. Bohn as general manager to succeed the late Joseph C. Gaskil. Mr. Bohn has served his company as cost accountant, assistant manager and more recently was plant manager of the Ames Works.

ORDER FOR boiler feed pump equipment for the Deepwater Point New Jersey Power Plant of the American Gas & Electric Co. has been awarded to the Ingersoll-Rand Co. Six 6-stage pumps will deliver water at 650 lb. pressure to the suction of six 5-stage pumps, which will deliver at 1600 lb. pressure, each pair of pumps having a capacity of 650,000 lb. of water an hour, operating at 3450 r.p.m.

SIXTH ANNUAL Convention of the American Institute of Steel Construction, Inc., will be held at Biloxi, Mississippi, November 13 to 17 inclusive, according to a recent announcement. Problems of merchandising and of standardizing of products will be the chief subjects for discussion, it was stated.

F. W. FISHBACK, president of the Electric Controller & Mfg. Co., Cleveland, O., has just been elected vice-president in charge of the Apparatus Division of the National Electrical Manufacturers Association, at a meeting of the executive committee of the Board of Governors. He replaces N. A. Wolcott, who recently resigned. In this office, Mr. Fishback will represent a group which includes about 85 per cent of all manufacturers of electrical apparatus and machinery in the country.

FOR INSTALLATION in its Northeast Station in Kansas City, the Kansas City Power & Light Co. purchased recently from the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., a 12,500-kv-a., 3600-r.p.m., two-pole, 60-cycle generator coupled to a 10,000-kw., 1200-lb pressure turbine. The generator uses internal fans, as in this installation it was impossible to obtain the required ventilation by the ordinary methods. The turbine is one of the first 1200-lb., 10,000-kw. units ever built and is the first of its kind produced by Westinghouse. The exhaust steam from this turbine, at about 385-lb. pressure, will be used to drive other units in the Northeast Station.

Catalog Notes

HIGH TEMPERATURE INSULATION designated as Bulletin 104 has been issued by the Los Angeles, California, office of the Celite Products Co. Conductivities of refractory, red brick and insulating materials have been determined based on mean temperatures of test specimens, and a new method of determining heat loss through walls is also included. The illustrations show the latest application of insulation in modern high temperature equipment.

BULLETIN No. 682 has just been issued by the Cochrane Corp., 17th and Allegheny Ave., Philadelphia, Pa., dealing with the Cochrane Discharger, which is a large capacity steam trap for high pressures.

SULZER DRY QUENCHER, type C for smaller gas and coke works, is described in publication DQ 3 issued by Dry Quenching Equipment Corp., 200 Madison Ave., New York, N. Y., a subsidiary of International Combustion Engineering Corp.

MASSACHUSETTS MODIFIED unit heaters of various types are described in a recent 24-page bulletin by the Massachusetts Blower Division of The Bishop & Babcock Sales Co., 4901 Hamilton Ave., N. E., Cleveland, Ohio. The bulletin describes several types of unit heaters, one including air filters, gives data on their installation, tables of dimensions and photographs of actual installations.

MCCLAVE SHAKING AND CUTOFF GRATES, Type 2-A, adaptable for both high-pressure and low-pressure settings, and designed for all bituminous and lignite fuels, are described in a recent, illustrated, eight-page bulletin sent out by McClave-Brooks Co., Scranton, Pa.

"CHARACTER AND USES of Norton Products" is the title of an attractive booklet just issued by the Norton Co. of Worcester, Mass. This publication deals with abrasives, giving many of their uses in industry including grinding, lapping and as refractories.

BAYLEY BLOWER CO., 732 Greenbush St., Milwaukee, Wis., has just issued an interesting bulletin dealing with induced draft and exhaust fans as applied to the firing of locomotives and exhausting of gases from railroad roundhouses.

FALK FLEXIBLE COUPLINGS, incorporating the spring groove design, are illustrated and described in bulletin No. 180, recently sent out by the Falk Corporation, Milwaukee, Wis.

BULLETIN No. 35 entitled "Bailey Gas Meters," has just been issued by the Bailey Meter Co., Cleveland, O. This describes a number of general types of meters for the measurement of various kinds of gases. In this bulletin are also illustrated and described various applications of meters for gas fired boilers, water gas sets, open hearth furnaces, blast furnace turbo blowers and other services. The principle upon which the Bailey meters operate is also shown by means of numerous cross-sectional and cut-away views.

Power Plant Construction News

Calif., Antioch—The Fibreboard Products, Inc., plans the installation of power equipment in proposed new local mill to cost about $250,000.

Colo., Calhan—The Common Council is said to be planning the installation of pumping machinery and auxiliary equipment in connection with a proposed municipal waterworks, for which estimates of cost and plans will be made by the Wieland Engineering Co., Pueblo, Colo., engineer.

Fla., Canal Point—The Southern Sugar Co., Clewiston, Fla., plans installation of power equipment in a proposed new sugar mill at Canal Point, with rated output of 2,500 tons per day, reported to cost in excess of $1,000,000.

Ill., Chicago—The Commonwealth Edison Co., 72 West Adams Street, has filed plans for the erection of a two and one-half story power substation, 100x160 ft., on Prairie Avenue, estimated to cost $200,000, with equipment.

Ill., Oak Park—The Pioneer Publishing Co., 1114 North Boulevard, plans the installation of power equipment in a new four-story printing plant to cost more than $250,000. S. N. Crowen & Associates, 22 West Monroe Street, Chicago, are architects and engineers.

Ind., Kendallville—The Kendallville Brush & Broom Co. plans installation of power equipment in connection with proposed rebuilding of plant destroyed by fire, September 25, with loss approximating $125,000.

Ind., Muncie—The Board of Public Works, Muncie, plans the installation of pumping machinery and power equipment in a proposed new municipal sewage disposal plant to cost close to $1,000,000. Pearse, Greeley & Hansen, 6 North Michigan Boulevard, Chicago, Ill., are engineers.

Iowa, Boone—The Iowa Railway & Light Co., Davenport, Iowa, is said to be planning extensions and improvements in power plant at Boone, to cost close to $200,000, with equipment.

La., Garyville—The Lyon Lumber Co. plans installation of power equipment in connection with proposed rebuilding of mill recently destroyed by fire with loss reported in excess of $300,000.

Mich., Detroit—The Briggs Mfg. Co., Mack Avenue, plans the installation of power equipment in a new one-story addition to automobile body-manufacturing plant to cost about $100,000. Albert Kahn, Inc., Marquette Building, Detroit, is architect.

Mich., Iron River—The Chicago & Northwestern Railway Co., 226 West Jackson Boulevard, Chicago, Ill., is said to be planning the installation of power equipment in a proposed engine house, machine shop and other locomotive shop units at Iron River, entire project to cost about $150,000.

Mich., Saginaw—The Consumers Power Co., Jackson, Mich., has plans maturing for a one-story power substation at Saginaw with capacity of 12,000 kva., reported to cost about $225,000. Albert Kahn, Marquette Building, Detroit, Mich., is architect.

Miss., Brookhaven—The Southern States Utilities Co., New Orleans, La., and associated interests are planning the construction of an artificial gas plant at Brookhaven, where franchise has been secured, to cost more than $175,000.

N. J., Newark—The Public Service Electric & Gas Co., Public Service Terminal, has filed plans for a two-story power substation on Norfolk Street, to cost about $45,000.

N. J., Princeton Junction—The Funk Printing Press Co., 150 Nassau Street, New York, will install power equipment in a proposed new local plant to cost more than $100,000.

N. Y., Binghamton—Baker Brothers, 8 South Street, plan the installation of power equipment in connection with proposed rebuilding of their flour and feed mills, destroyed by fire September 25, with loss reported at close to $100,000.

N. Y., Brooklyn—Charles Pfizer & Co., Inc., 81 Maiden Lane, New York, plan installation of power equipment in a seven-story chemical factory on Harrison Avenue, Brooklyn, to cost about $300,000. Henry Holder, 242 Franklin Avenue, Brooklyn, is architect.

N. Y., New York—The Board of Trustees, American Museum of Natural History, has plans maturing for a five-story power house and service station on museum grounds at Columbus Avenue and Seventy-seventh Street, to cost in excess of $750,000, with equipment. Trowbridge & Livingston, 527 Fifth Avenue, New York, are architects and engineers.

N. Y., New York—The Pan-American Petroleum & Transport Co., 120 Broadway, New York, plans construction of boiler plant and installation of power equipment for oil refining service at its proposed new refinery on the Island of Aruba, Danish West Indies, entire project reported to cost close to $10,000,000.

N. C., Asheville—The American Enka Corporation, 114 East Thirty-second Street, New York, plans the construction of a boiler plant at its proposed local rayon mill, for which tract of 2000 acres of land near Asheville has recently been acquired. Entire project is reported to cost more than $5,000,000.

Ohio, Chillicothe—The Mead Pulp & Paper Co. will install power equipment in connection with extensions and improvements in local mill estimated to cost more than $100,000.

Okla., Duncan—The Common Council is planning the installation of a municipal ice-manufacturing plant, to be equipped for an initial output of about 50 tons per day.

Okla., Shawnee—George Russell, Picher, Okla., and associates have preliminary plans under way for the construction of two ice-manufacturing plants to be located at Shawnee and vicinity, reported to cost more than $75,000, with equipment.

Pa., Chester—The City Council has secured permission from the state for construction of municipal pumping station and installation of sewage system, to cost about $200,000. A bond issue in this amount is being arranged.

Pa., Philadelphia—Morris, Wheeler & Co., 300 South Thirteenth Street, iron and steel products, have authorized plans for the construction of a power plant at proposed new mill at Fox and Roberts Streets, entire project to cost more than $1,000,000. Julian S. Simsohn, Broad Street and Girard Avenue, is engineer.

Tenn., Knoxville—The Atlantic Ice & Coal Co., 106 Collins Street, Atlanta, Ga., is said to have plans under way for construction of ice manufacturing and cold storage plant on West Cumberland Avenue, Knoxville, to be two and four-story, respectively, reported to cost about $185,000. Ice unit will be equipped for output of 200 tons per day.

Texas, Bartlett—The Common Council is reported to be planning the installation of a municipal electric light and power plant, and will make estimates of cost at an early date.

Texas, Pampa—The Forest E. Gilmore Co., Wright Building, Tulsa, Okla., plans installation of power equipment, with boiler house, in connection with proposed gasoline refining plant in Gray County, near Pampa.

Texas, Waco—The Atlas Portland Cement Co. of Texas, Waco, operated by the Atlas Portland Cement Co., 25 Broadway, New York, plans construction of a large boiler plant and installation of other power equipment at its proposed local mills, for which tract of land has been purchased, entire project to cost more than $1,500,000.

Va., Richmond—The Richmond Car Works, Inc., plans installation of power equipment in connection with an expansion and improvement program to cost more than $400,000. The company is a subsidiary of the Standard Steel Car Co., Pittsburgh, Pa.

Wash., Seattle—The Great Northern Railroad Co., King Street Station, will install power equipment in a new engine house and repair shops on Twentieth Avenue, west, entire project to cost close to $200,000.

Wash., Seattle—The Municipal Power Bureau, Seattle, is said to have plans maturing for its proposed municipal hydro-electric power development at Diablo dam, reported to cost close to $3,000,000, with transmission system. A bond issue in amount noted is being arranged.

Wash., Tacoma—George M. Harty Lumber & Mfg. Co., East M Street, plans installation of power equipment in connection with proposed rebuilding of sash and door mill recently destroyed by fire with loss estimated at more than $100,000.

Wis., Menasha—The John Strange Paper Co., Washington Street, has had plans prepared for a one-story boiler plant at its mill. Orbison & Orbison, 110 West College Avenue, Appleton, Wis., are engineers.